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Book of abstracts

VLIZ YOUNG MARINE SCIENTISTS' DAY

KHBO, Brugge
24 February 2012

VLIZ

VLIZ SPECIAL PUBLICATION 55

VLIZ YOUNG MARINE SCIENTISTS' DAY 2012

BOOK OF ABSTRACTS

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Photo cover:
Groyne covered with green algae: an example of a coastal defence structure at the Belgian coast (Tineke Seys)

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PREFACE

This is the 'Book of Abstracts' of the 12th edition of the VLIZ Young Scientists' Day, a one day event that was organized on 24 February, 2012 in KHBO, Brugge.

This annual event has become more and more successful over the years. With more than 300 participants and over 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where young scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders in 2012. Young scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visiblity.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

I want to congratulate all participants with their contributions, and I invite them all to actively participate in VLIZ-events and activities in the future.

Brugge, 24 February 2012

Dr Jan Mees
Director VLIZ

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ANNUAL VLIZ THESIS AWARDS MARINE SCIENCES 2011

Every year VLIZ awards two marine Master theses. Fundamental as well as applied marine researchers in all disciplines of marine sciences can apply. The prize amounts to 500 EUR and is reserved for young scientists that are graduated at a Flemish university or college for higher education.

The 2011 winners of the Annual VLIZ Thesis Award Marine Sciences are:

ELISABETH DEBUSSCHERE

Marine Biology, Ghent University
Erasmus Mundus Marine Biodiversity and Conservation

for the thesis entitled:

DE IMPACT VAN DE VERZURING VAN DE OCEANEN OP DE VROEGE LEVENSSTADIA VAN HET NONNETJE *MACOMA BALTHICA*

&

LORENZ MEIRE

Marine Biology, Ghent University
Marine and Lacustrine Sciences (Marelac)

for the thesis entitled:

DE INVLOED VAN GLOBALE KLIMAATSVERANDERING OP HYPOXIA

De impact van de verzuring van de oceanen op de vroege levensstadia van het nonnetje *Macoma balthica*

Debusschere Elisabeth

Mariene Biologie, Universiteit Gent, Erasmus Mundus Marine Biodiversity and Conservation, Campus De Sterre s8, Krijgslaan 281, B-9000 Ghent, Belgium
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De verzuring van de oceanen wijzigt de chemische samenstelling van het zeewater en vormt een bedreiging voor mariene organismen. Calcificerende organismen zijn rechtstreeks afhankelijk van de carbonaat concentratie in de oceanen en zijn hierdoor de eerste groep die negatieve effecten zal ondervinden door de pH dalingen. Daarbovenop zijn de jongere levensstadia gevoeliger voor veranderingen in omgevingsvariabelen. Dit onderzoek richt zich op de effecten van de toenemende pCO_2 en de geassocieerde pH daling op de vroege levensstadia van het nonnetje (*Macoma balthica*), een wijdverspreide en belangrijke bivalve in het functioneren van kust-ecosystemen. Bevruchtingssucces, embryonale en larvale ontwikkeling werden onderzocht onder 3 pH condities (pH_{NBS} ~ 8.11; pH_{NBS} ~ 7.79; pH_{NBS} ~ 7.56). Na 24 uur was het bevruchtingssucces enkel significant gereduceerd met ~15.3% onder de laagste pH (pH_{NBS} 7.66). De embryonale ontwikkeling vertoonde vergelijkbare hatching rates na 3 dagen bij pH_{NBS} 8.11 en pH_{NBS} 7.77 maar de hatching rate bij pH_{NBS} 7.54 was significant gereduceerd met ~62.4%. In tegenstelling tot het uitblijven van significante effecten tijdens bevruchting en embryonale ontwikkeling bij pH_{NBS} ~7.77, werd de larvale ontwikkeling (dag 3 tot 19) hieronder wel gewijzigd. Het sterftecijfer (d^{-1}) steeg en groeisnelheden ($\mu m\ d^{-1}$) daalden terwijl de larvale ontwikkeling verliep zonder vertragingen. Het is opmerkelijk dat een pH daling van ~0.55 geen grotere impact uitoefende dan een pH daling van ~0.32. Ondanks deze reducties zijn de gameten van *Macoma balthica* nog steeds in staat bevruchting uit te voeren en kunnen de embryo's en larves zich ontwikkelen in zeewater dat onverzadigd is ten opzichte van carbonaat. Niettemin zullen de waargenomen stijging in mortaliteit en de vermindering in groei de sterfte tijdens de pelagische fase van het nonnetje verhogen. Bijgevolg zullen toekomstige *Macoma balthica* populaties waarschijnlijk inkrimpen onder invloed van toenemende koolstofdioxide en afname in pH.

De invloed van globale klimaatsverandering op hypoxia

Meire Lorenz

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De opgeloste zuurstofconcentratie in waterlichamen wordt bepaald door de balans tussen de consumptie (voornamelijk door biologische processen) en toevoer (hoofdzakelijk door fysisch transport van zuurstof) (Diaz, 2001; Middelburg en Levin, 2009. Als de zuurstofconcentratie door een onbalans tussen consumptie en toevoer onder de grenswaarde van 63µM (2mg.l^{-1}) zakt, wordt het fenomeen hypoxia genoemd (Pena *et al.*, 2010; Rabalais *et al.*, 2010). Er wordt een onderscheid gemaakt tussen het verlies van zuurstof in de open oceaan en het voorkomen van lage zuurstofconcentraties in kustgebieden (Diaz and Rosenberg, 2008; Keeling *et al.*, 2010). Veranderingen in de zuurstofconcentratie in de open oceaan worden voornamelijk gedreven door klimaatseffecten. Op deze manier zal ook klimaatverandering de zuurstofconcentratie in de open oceaan op verschillende manieren beïnvloeden. Warmere wateren leiden vooreerst tot een verlies van zuurstof door een verminderde oplosbaarheid. Zo voorspellen globale oceaanmodellen een afname van de globale zuurstofconcentratie met 1 tot 7% tegen het einde van deze eeuw (Keeling *et al.*, 2010). Aan de andere kant leiden hogere watertemperaturen ook tot een versterkte stratificatie. Bijgevolg wordt het transport van zuurstof naar de diepere bodemlagen geblokkeerd (Conley *et al.*, 2009; Keeling *et al.*, 2010; Pena *et al.*, 2010; Rabalais *et al.*, 2010). Een verhoogde watertemperatuur heeft bovendien ook een invloed op tal van biologische processen zoals de respiraie van organismen en de mineralisatiesnelheid. Naast het verlies van zuurstof door fysische factoren leiden de voorspelde hogere temperaturen dus ook tot een hogere biologische zuurstofvraag (Conley *et al.*, 2009).

Maar naast een verandering in de watertemperatuur voorspellen klimaatsmodellen ook een verschuiving in de windpatronen en veranderingen in zowel de intensiteit en het moment waarop stormen voorkomen. Dit kan leiden tot een frequenter verbreken van stratificatie in de zomerperiode en zodoende tot een verhoogde aanvoer van zuurstof naar de bodemlagen. De deterministische trend tot een daling van de zuurstofconcentratie als gevolg van hogere watertemperaturen kan dus verbroken worden door frequentere stochastische wind events. Het netto-effect van klimaatsverandering op het verloop van de zuurstofconcentratie is een eerste onderzoeksvraag die in deze thesis onderzocht wordt.

Daarnaast worden kustgebieden ook nog beïnvloed door een toenemende flux van nutriënten vanuit het land. Deze sterk toegenomen nutriëntenflux leidt tot een sterk toegenomen fotosynthese in de kustgebieden. Dit resulteert in een toegenomen transport van organisch materiaal naar de diepere waterlagen en het sediment en bijgevolg tot een hogere zuurstofvraag daar (Diaz and Rosenberg, 2008; Conley *et al.*, 2009). Deze toegenomen input van nutriënten ten gevolge van menselijke activiteiten zorgt sinds 1960 voor snelle veranderingen in de zuurstofconcentratie in kustecosystemen. Voor 1950 waren wereldwijd slechts een aantal gebieden aangetast door hypoxia. Dit aantal is toegenomen tot meer dan 400 op dit moment met een totaal oppervlak van meer dan 245.000km^2 (Diaz and Rosenberg, 2008; Zhang *et al.*, 2010). Een tweede onderzoeksvraag in deze masterthesis is bijgevolg wat het belang is van nutriëntfluxen naar kustgebieden en zeker in combinatie met klimaatsverandering in de ontwikkeling van hypoxia.

Om deze onderzoeksvragen te beantwoorden werd een één-dimensioneel model ontwikkeld dat zowel de fysische en biologische condities in de centrale Noordzee (Oestergronden) beschrijft. Er werd gekozen om de situatie in de Oestergronden (54°30' N and 4°30' E) te modelleren daar in het verleden daar reeds lage zuurstofconcentraties doch geen hypoxische zuurstofconcentraties gemeten werden (bijvoorbeeld een zuurstofconcentratie van 65µM in oktober 2003) (Weston *et al.*, 2008; Greenwood *et al.*, 2010).

In eerste instantie werd het ontwikkelde model gebruikt om de fysische watercondities in de Oestergronden voor het jaar 2007 te modelleren. Atmosferische simulaties afkomstig van het ECHAM5/MPI-OM klimaatsmodel voor de periode 2000-2010 werden gebruikt om de waterkarakteristieken (watertemperatuur en -menging) te berekenen met het fysisch "k-ε turbulence closure" model (Gaspar et al., 1990; Soetaert et al., 2001). Vervolgens werden de resultaten van dit fysisch model gebruikt om het gekoppeld pelagisch-benthisch model aan te drijven. In dit

gekoppeld model wordt het verloop van zuurstofconcentratie en een serie andere biochemische variabelen (bijvoorbeeld nitraat- en fytoplanktonconcentratie) berekend.
De modeloutput van het ontwikkelde fysisch-biogeochemisch model werd vergeleken met de beschikbare CEFAS en rijkswaterstaat dataset voor het jaar 2007 van de Oestergronden. Validatie met deze data toont aan dat het model in staat is om zowel de fysische (zoals temperatuur) en biochemische factoren (waaronder de zuurstof) vrij accuraat te reproduceren.

Na de validatie van het model voor het heden werd het model vervolgens gebruikt om een inschatting te maken van hoe de zuurstofconcentratie en voornamelijk het voorkomen van hypoxia zal evolueren in de toekomst (periode 2090-2100). De atmosferische simulaties, die het model aansturen, tonen aan dat de luchttemperatuur gemiddeld met 2.4°C zal toenemen in de centrale Noordzee tegen 2100. In de ECHAM5/MPI-OM simulaties blijkt de windsterkte echter niet significant te veranderen.

Gebruikmakend van deze projecties van de atmosferische condities, tonen simulaties voor het fysisch model dat de watertemperatuur gemiddeld met 2.1°C zal toenemen tegen 2100. Verder neemt de periode waarin de waterkolom gestratifieerd is toe met tien dagen. Deze condities leiden ertoe dat het risico op hypoxia in de Noordzee zal toenemen in de toekomst. Gemiddeld voorspelt het model een afname van de zuurstofconcentratie met 17µM (7%). Deze afname kan toegewezen worden aan 3 verschillende factoren. Een eerste belangrijke factor is de verminderde oplosbaarheid van zuurstof bij hogere watertemperaturen. Daarnaast speelt ook de versterkte stratificatie ook een zeer belangrijke rol. Door het verlengen van de stratificatie met tien dagen zijn de bodemlagen langer geïsoleerd en zakt de zuurstofconcentratie bijgevolg tot lagere waarden. Tot slot kan een klein gedeelte van de lagere zuurstofconcentratie in de bodemlagen toegewezen worden aan een versnelde koolstofkringloop wat leidt tot een verhoogde biologische zuurstofvraag.

Naast het effect van klimaatsverandering werd ook het effect van eutrofiëring onderzocht. Simulatie tonen een duidelijke link tussen een hogere pelagische stikstofconcentratie en het voorkomen van lagere zuurstofconcentratie in de bodemlagen. Het model toont aan dat door een combinatie van natuurlijke variatie in de stikstofconcentratie en ongustige atmosferische condities reeds nu al in de Oestergronden lage zuurstofconcentraties kunnen voorkomen. Deze bevinding werd ook in praktijk geobserveerd zoals bijvoorbeeld in oktober 2003 waar bijna hypoxische zuurstofconcentraties werden gemeten na een zeer warme zomer. Dit leidt ertoe dat in de toekomst in combinatie met klimaatsverandering de probabiliteit van een hypoxisch event vermoedelijk sterk zal toenemen. Dit toont aan dat het in de toekomst belangrijk zal zijn om de nutriëntfluxen nog beter te controleren om er zo zeker van te zijn dat onder een combinatie van klimaatsverandering en hoge nutriëntconcentraties geen hypoxia optreedt in de centrale Noordzee.

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ANNUAL VLIZ NORTH SEA AWARD – 2011

Each year the Flanders Marine Institute (VLIZ) awards a scientific prize to foster innovative fundamental or applied research on the structure and functioning of the North Sea ecosystem, with emphasis on coastal and estuarine areas of the Southern Bight and the Channel. The prize is awarded to a researcher (or a research team) working and residing in a country bordering the North Sea. The prize amounts to 1000 EUR and is indivisible. It is granted to reward a recent original scientific contribution, preferably having relevance to the sustainable management of the area concerned. Studies pertaining to the biodiversity of the local ecosystem are equally welcomed. The contribution has to be of postgraduate or postdoctoral level.

The Annual VLIZ North Sea Award 2011 is awarded to:

ERIC STRUYF

Dept Biology, University of Antwerp

for his scientific contribution entitled:

HISTORICAL LAND USE CHANGE HAS LOWERED TERRESTRIAL SILICA MOBILIZATION (TO THE NORTH SEA AND THE SCHELDT ESTUARY)

Historical land use change has lowered terrestrial silica mobilization (to the North Sea and the Scheldt Estuary)

Struyf Eric

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It has recently been shown that intense biogeochemical cycling of silica occurs in terrestrial soils. The annual ecosystem biogeochemical cycling of Si exceeds the annual export from the continents to the coastal zone by two orders of magnitude and effectively buffers weathering Si fluxes. Given the importance of the ecosystem biological Si filter, human impacts on vegetation cover through land use changes will significantly alter the biogeochemical silica cycle, although the impacts on the magnitude and fluxes of silica from land to coastal zones are presently unknown. Addressing this knowledge gap is essential as the terrestrial silica cycle is closely connected to i) important terrestrial and ocean carbon sinks and the ii) occurrence of harmful algal blooms in adjacent coastal ecosystems.

We showed that land use is the most important controlling factor on baseflow Si mobilisation in the river basin of the Scheldt Estuary, with historical soil disturbance and sustained cultivation (> 250 years) of formerly forested areas leading to two- to threefold decrease in baseflow delivery of Si from the land surface to the estuary. We propose a new conceptual model where initial deforestation leads to increased Si fluxes, with sustained soil disturbance depleting soil pools of amorphous silica, eventually leading to reduced Si fluxes. The Scheldt basin has been one of the most densely populated areas in Europe already since the 13th century. As early as 1250, only 10% woodland cover remained; in a pristine state the Scheldt basin was almost fully forested (>90 %). In this conceptual model, the present Scheldt basin therefore represents a new equilibrium state.

Despite limiting our study to base-flow conditions (60-90% of total yearly water fluxes) and the uncertainty associated with the timeframes in the new conceptual model, our data clearly indicate that long-term soil disturbance and a millennium of agricultural development has strongly changed biogeochemical Si dynamics in the Scheldt River basin (and likely other temperate river basins). Modern agricultural practices also result in increased input of N and P to the aquatic continuum, resulting in Si limitation in the Scheldt Estuary, with negative effects on ecosystem quality including the development of harmful algal blooms. Our new hypothesis suggests this DSi limitation in aquatic systems could be counteracted initially by increased Si export from cultivation of former forest soils. As the soil biogenic Si pool gradually declines, this counter-effect diminishes and Si mobilization becomes lower compared to pristine conditions. This implies that Si depletion events in more recently cultivated areas could currently still be masked by increased DSi export fluxes from recyclable biogenic Si pools. In the Scheldt watershed, lowered Si fluxes were already attained long before intense fertilization started, and no such masking was observed.

Our observations emphasize the need to increase our understanding of land use impacts on biogeochemical Si cycling. A millennium of soil disturbance after deforestation lead to 2-fold to even 3-fold decreases in TSi flux from a watershed where the adjacent coastal zone has experienced significant eutrophication problems due to changed N:P:Si river deliveries in the last three decades. Our results are the first to show that locally factors controlling terrestrial Si mobilization can be separated from factors important at continental and global scales, where controlling factors largely include lithology, precipitation and slope. We clearly show that land use should be included in watershed scale models for baseline Si mobilization. Our results shed new light on how historical cultivation has affected the terrestrial silica cycle, and indicate yet another anthropogenic reduction of silica fluxes through the aquatic continuum, adding to globally important reductions in riverine Si transport by deposition in reservoirs and in eutrophicated rivers and estuarine sediments.

The observation that long-term soil disturbance has lowered baseflow mobilization of Si from landscapes is novel and part of a complex puzzle linking Si, N, and P continental biogeochemical cycles to the ecological quality of coastal waters and C burial in the ocean. Transport of nutrients to the coastal zone and the ocean will be strongly dependent on processing within estuaries. The yearly average filtering capacity (the ratio of the net process rate to the total inputs) of the Scheldt Estuary is 0.12 for DSi, with strong seasonal fluctuations. In addition, tidal marshes will play an important role in estuarine Si fluxes, especially in summer. Ratios of processed nutrients in the estuary may also vary with discharge. Increasing discharge lowers diatom uptake of Si within the estuary, while increasing the net amount of TSi transported through the estuary. Yet, the average filtering capacity demonstrates that riverine inputs of Si are an important determining factor for eventual fluxes to the coastal zone, and a good understanding of the effect of land use in Si dynamics is therefore essential.

ORAL, POSTER & DEMO PRESENTATIONS

EU FP7 BAMMBO: sustainable production of Biologically Active Molecules of Marine Based Origin

Allewaert Céline, Annick Verween and Wim Vyverman

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The current growing demand for marine resources, in particular High Value Added molecules (HVAB's) could pose a serious threat to marine ecosystems and marine biodiversity. Instead of exploiting the natural marine resources, environmental friendly and economically sustainable ways for culturing organisms with economically interesting composition should be developed. The FP7 project BAMMBO addresses all key issues associated with the culture of marine organisms and will overcome these bottlenecks by designing economically sustainable and scalable culturing methodologies for industrial scale production of high added values compounds. For this purpose, the BAMMBO consortium has identified three microalgal species: *Phaeodactylum tricornutum*, *Cylindrotheca closterium* and *Haematococcus pluvialis* as model species. All three are producers of bioactive molecules: EPA, fucoxanthin and astaxanthin, respectively. The production of HVAB's is often elicited by the alteration of environmental and nutrimental parameters, so called abiotic stressors. This study within the project focuses on the optimization of growth, harvest and screening of *P. tricornutum*, *C. closterium* and *H. pluvialis*. The elicitation of secondary metabolites is investigated *in vitro* at the flask scale by measuring metabolite production in response to various stresses.

How many known species in the Ocean and in WoRMS?

Appeltans Ward[1], Mark J. Costello[2], Wim Decock[1], Bart Vanhoorne[1], Klaas Deneudt[1] and Francisco Hernandez[1]

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Since the time of Linnaeus 250 years ago, 239,000 marine species have been described and classified into 89 Phyla. The World Register of Marine Species (Appeltans *et al.*, 2012) is the most complete register of all marine species names worldwide. Iit holds accepted names, but also synonyms, common misspellings, and a hierarchical classification. Its online database is edited by over 200 world-leading taxonomists from 27 countries. WoRMS currently has 360,000 names for 213,000 species. The number of marine species described as new to science is growing at a current rate of 2,000 species per year. The Ocean's biodiversity contains the following Kingdoms, (number of phyla) and currently described species:

	Number of Phyla	Species
Plantae	6	7,600
Chromista	11	20,000
Protozoa	7	500
Fungi	5	1,000
Bacteria	26	1,700
Archaea	4	117
Animalia	30	208,000

The most species rich groups of marine animals are:

Annelida	**13,700**	
Polychaeta		12,600
Crustacea	**51,700**	
Brachyura		7,000
Amphipoda		7,000
Isopoda		6,200
Copepoda		10,000
Ostracoda		9,000
Bryozoa	**5,900**	
Pisces	**17,000**	
Cnidaria	**10,200**	
Hexacorallia		3,100
Octocorallia		3,100
Hydrozoa		3,400
Echinodermata	**7,400**	
Mollusca	**56,700**	
Bivalvia		9,000
Gastropoda		45,000
Nematoda	**11,400**	
Platyhelminthes	**11,700**	
Porifera	**8,500**	

A full overview of the number of species described, the number of times species have been described, how many more species are collected, but not yet described and how many remain undiscovered (including those that are only distinguishable by molecular techniques) will be published in a multi-author paper lead by Ward Appeltans and Mark Costello.

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Environmental impacts on the Galapagos Islands: identification of interactions, perceptions and steps forward

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Environmental impacts due to anthropogenic pressures are reaching critical levels worldwide and are more noteworthy on small oceanic islands. The reduced area, isolation, exposure to natural disasters, fragile ecosystems, and shortage of natural resources, demographic pressure and economic fragility make the environmental problems of islands very serious. The Galapagos Islands, known as a unique place of ecological diversity and of evolutionary importance in the world, has also become a place of societal development that today harbours more than 25,000 inhabitants. In the past decades important socio-economic activities (e.g. fisheries and agriculture) have developed and are attributed the growth in the number of tourists (173,000 per year) and the tourism industry which generates more than 65% of Galapagos GDP. As a consequence, socio-economic growth has created and triggered environmental degradation in the fragile ecosystems of the Archipelago. Certainly, the evaluation of environmental impacts on islands will require multiple indicators appropriate for measuring the state and interactions of the interrelated social and environmental variables. However, in many cases, the selection of such indicators is not correctly addressed. Societal and environmental indicators are analysed separately with no assessment of interconnections. Consultation processes that should involve a wide spectrum of stakeholders, capable of better representing context specific indicators, are not taken into consideration. As a consequence, the distance between decision makers and local population increases, and environmental impacts mitigation strategies ultimately do not yield results. The present research proposed a participatory approach to understand the perception of environmental impacts and to develop responsive impact mitigation strategies in the Galapagos Islands. The Drivers-Pressures-State-Impact-Responses (DPSIR) framework provided an analytical lens, while the Delphi approach was chosen to involve selected Galapagos experts in the process. The Delphi approach allowed a systematic collection of the experts' opinions on the environmental and societal issues and structured through the DPSIR framework. The Delphi consists of a sequential set of questionnaires, interspersed with feedback from earlier responses and organised in two or more rounds. After the first round of open questions of the Delphi, 55 indicators and 28 interactions of environmental impacts were determined in total. Together they represented the causal chain of events of the DPSIR framework. Finally, after the second and third round of the Delphi 37 out of the 55 indicators, organised under a five point rating scale (1=non important to 5=very important), reached statistical consensus ($qi \geq 3.5$ and $Q \leq 0.5$); whereas 7 out of 28 interactions of environmental impacts were selected as the most important ones (Mean≤0.5 and CV≤0.5) during the second and third round. Findings of this study highlights the potential of the Delphi to develop locally supported and context-specific indicators that will hopefully allow Galapagos decision makers to deliver policies that properly address environmental impacts, in order to move towards sustainability and towards the proper management for the conservation of the islands.

Why do we love the sea?
Because it makes us think of things we like to think[1]

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The Belgian coastal zone offers quite a number of scientific and engineering challenges.

The actual level of safety is at several places considerably less than the 'once in 1000 years' standard. Patches of beaches and dunes are threatened. The expected sea level rise, due to the imminent climate change will increase the challenge. This has prompted the Flemish government recently to approve an integrated safety plan for the coast; some urgent measures are already taken.

The accessibility of the harbours of Ostend and Zeebrugge requires frequent dredging and important infrastructure works. The Scheldt Estuary needs continuous maintenance dredging, which entails the problem of where to dispose the dredged material, in particular mud, which may be contaminated. Clever solutions can turn a problem into an opportunity, avoiding morphological deterioration of the estuary and fostering biodiversity by re-creating mud flats or extending existing ones.

Natural reserves are threatened (e.g. the Zwin), others are newly appearing (Heist) or are being recreated (e.g. mouth of the IJzer).

To be prepared for all these challenges, research had been done: both fundamental work to understand the physics better (e.g. mud behavior, nautical depth, sediment transport) and applied research by testing different designs or management plans. However, more research is still needed to fill knowledge gaps (e.g. the effects of waves breaking against a dike and of dike overtopping), or to address new problems (e.g. off shore wind farms or even artificial islands!).

Although physical models are still used to support and underpin the design of infrastructure works or coastal protection plans, numerical models are now used routinely. However, no model includes all relevant physical processes in sufficient detail and/or all their interactions. A numerical model is a 'model' indeed and thus represents the reality only partially. Often, also the available data are not sufficient to calibrate and validate the models properly. The use of new technologies (e.g. using satellite images or airborne sensors, producing spatially distributed data) may improve on that.
Anyhow, model results must be interpreted with care and expert knowledge.

[1] After Robert Henri (1865-1929).

Light stress in intertidal diatoms: a comparative molecular and ecophysiological study

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Intertidal sediments are extreme environments, characterized by rapid changes in environmental conditions such as irradiance as a result of the interplay of tides, weather and biology. Nevertheless, intertidal sediments belong to the most productive systems on Earth (Underwood and Kromkamp, 1999) owing to the primary production of microphytobenthos, sediment-inhabiting micro-algae, (Cook *et al*., 2007). Benthic diatoms thriving in these conditions can be divided into three groups: The epipelon, which consists of motile diatoms, mainly living on silty sediments, the epipsammon which are immotile and live attached to sand grains and the tychoplankton, which can be found both on the sediment as in the water column. As these groups show marked differences in life style, they are expected to show different responses in coping with intense light and rapid fluctuations in light climate. In this study we compared the response to high light of the model tychoplanktic diatom (*Phaeodactylum tricornutum*) and the recently sequenced epipelic diatom *Seminavis robusta*. Our study revealed pronounced differences in photophysiology and expression of genes involved in photosynthesis in both diatoms when exposed to high light. Our study is the first to describe the molecular acclimation of an epipelic diatom and reveals a different way to cope with high light. Current research focuses on different physiological processed involved.

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FLUXMAP: an ecosystem functioning map of the Belgian part of the North Sea

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The European Marine Strategy Framework Directive urges member states to establish and implement coordinated monitoring programmes for the assessment of the environmental status of their marine waters. These monitoring programmes need to be rooted in the currently best knowledge on our marine areas. The Belgian part of the North Sea (BPNS) is one of the best documented of such marine areas. Many maps exist on the physico-chemical properties of sediment and water, the biodiversity of their inhabiting biological communities and the variety of users of the sea and its sediments.

The biological value of a specific area of the sea floor is often based on biodiversity maps. However, the value of the benthic ecosystem involves more than biodiversity: it also encompasses ecosystem functioning. In coastal systems, a close coupling between the pelagic and the benthic ecosystem exists. As such, the phytoplankton dynamics are dependent on the nutrient release from the benthic part and the productivity of the benthic system is influenced by the amount of organic matter that arrives from above. The oxygen consumed during organic matter mineralization at the sea floor and the release of nutrients to the overlying water column characterize these mineralization processes. In addition, the maximum oxygen penetration depth in the sea floor indicates areas sensitive to seasonal hypoxia. Alkalinity generation in sediments informs us about the actual CO_2 uptake capacity of the overlying water, and is thus related to ocean acidification. Macrobenthos influences these ecosystem functions through their bioturbation and bio-irrigation activities. Based on the motility and sediment reworking properties, the Bioturbation Potential of the community (BPc) can be calculated, which establishes an easy link between the mineralization processes measured and the organisms influencing these functions.

In the project FLUXMAP, we sampled 10 sediment types representative of the range in sediments and macrobenthic communities on the BPNS on a monthly basis during the year 2011. Cores were incubated in the lab and oxygen, nutrient and alkalinity fluxes at the sediment-water interface were measured. The sediment was further profiled in terms of oxygen and pH. Macrobenthos was retrieved from the sediments and the Bioturbation Potential of the community was calculated.

Based on our flux measurements, we will be able to produce a full coverage ecosystem functioning map of the sea floor of the BPNS. Linking our flux data with macrobenthic data will enable linking ecosystem functioning with macrofaunal diversity on BPNS scale. This, together with the existing biodiversity maps, enables policy makers to make scientifically sound decisions on which areas to protect and how to ensure their protection. In addition, our results can provide a basis for the evaluation of descriptor 6 (Seafloor integrity) in the MSFD framework.

Micronecton analysis from the insular shelf of the Kerguelen islands: the case of the amphipod *Themisto gaudichaudii*

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Abundance and size structures of the hyperiid amphipod *Themisto gaudichaudii* were analysed in order to describe this species' potential habitats in the Kerguelen Islands Waters, Southern Indian Ocean. The analysis of the samples (obtained during February 1987 SKIF SKALP cruise) showed a density range from 10.98ind.m-3 near the south-west coast to 0.07ind.m-3 at the most southern stations in the open waters. The spatial distribution of *T. gaudichaudii* is correlated with hydrological parameters of the water masses in the area; the southern boundary of this species being marked by the Antarctic Polar Front. The variation of the density around the islands follows the patterns of primary production, with values decreasing from the coasts to the open waters.

With body length ranging between 1.9 and 28mm, the size structure analysis evidenced the presence of three cohorts in the *T. gaudichaudii* population around Kerguelen Islands, at the end of southern summer: (1) juveniles – comprising individuals smaller than 10mm; (2) first year individuals with a size range from 10 to 20mm; (3) second year individuals with body length exceeding 20mm.

The results were compared with the data of the Birds Zooplankton Interactions Program (IOZ), representing the *T. gaudichaudii* population of the Morbihan Gulf and the individuals from the stomachs of the island's birds for the same period of the year. The comparison showed differences in spatial distribution of the size structures; a dominance of juveniles in the SKALP stations at the end of southern summer is in contrast with the IOZ population dynamics studied in the area. This variation may be explained by differences in sampling technique, sampling at the SKALP stations used a Bongo net which is adapted to smaller size individuals, while the sampling in the Morbihan Gulf (IOZ) used a bigger mesh size net, the OMORI net, therefore the results showed the dominance of the medium size individuals. An observed absence of larger individuals from the coastal stations suggests a migration of the adults to the open ocean waters after their first year of life. This assumption is supported by the gut contents of the birds living on the islands which feed mainly on *T. gaudichaudii*.

The georeferenced data obtained during this study, in terms of abundance and size structures, were used to map the spatial distribution of the *T. gaudichaudii* around the Kerguelen Islands, thus integrated as GIS maps.

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A historical view of the macrobenthic communities on the Thorntonbank and Goote Bank

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The first offshore wind farm in the Belgian part of the North Sea became functional in May 2009 on the Thorntonbank. This sandbank is situated 27km offshore and contains coarse, sandy sediments with a relatively poor macrobenthic community, dominated by a few species (Reubens *et al.*, 2009). In 2005, a monitoring programme was initiated to determine the baseline situation of the soft-sediment macrobenthos in this area (De Maersschalck *et al.*, 2006). Since 2008, samples have been taken yearly to determine any primary impacts on the community that could have arisen during and after construction. However, before any impacts can be detected it is crucial to understand the long-term natural fluctuations of the macrobenthic communities as a result of sediment movements, plankton blooms, eutrophication, industrial and fishing activities or even climate change. Any impacts caused by the construction of offshore wind farms can subsequently be separated from natural fluctuations in the macrobenthic community (Hiscock *et al.*, 2002).

The historical and recent monitoring data were integrated into the Marine Biology Macrobenthos database (Macrodat) which contains information on macrobenthic densities together with relevant abiotic factors such as median grain size, total organic matter content and temperature. A temporal analysis was carried out over a period of approximately 30 years starting from 1979 until 2005 for the Thorntonbank and 1980 until 2011 for the Goote Bank (reference stations). Only samples taken during autumn were analysed as macrobenthic densities can differ greatly between seasons. The data was analysed at different levels to study the reaction at station and sandbank level and integrate the habitat suitability communities. These communities were characterised by means of sedimentological characteristics (median grain size and mud content) and can be divided into four groups: the *Nephtys cirrosa*, *Abra alba*, *Ophelia limacina* and *Macoma balthica* community (Van Hoey *et al.*, 2004; Degraer *et al.*, 2009).

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Habitat use and implications for the conservation of a population of bottlenose dolphins, *Tursiops truncatus*, in the San Antonio Bay, Rio Negro province, Argentina

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The San Antonio Bay, in Patagonia (Argentina) harbors a resident population of bottlenose dolphins (*Tursiops truncatus*). It seems to be a privileged area to give birth and nurse their young (Vermeulen *et al.*, 2009; Vermeulen *et al.*, 2010). Given that the species has been declining throughout the world and more particularly in South America (Bastida *et al.*, 2003), the population of San Antonio Bay takes its whole significance. However, human population growth and touristic development, especially dolphin-watching activities, represent a potential threat for the dolphin population (Lusseau *et al.*, 2004; Mattson *et al.*, 2005). Meanwhile, its residency makes it an adequate subject for long term studies which are essential for the understanding and the appropriate management of the subspecies *Tursiops truncatus gephyreus* (Vermeulen *et al.*, 2010). The aim of this study was to understand the bottlenose dolphin's habitat use inside the bay. This work also aimed at putting back the results into the human population growth and tourism development context. For this purpose, three months were spent on the field to collect data, between January and May 2011. In total, 25 boat-based surveys were carried out in the bay, covering approximately 164km², and 21 of these surveys were positive allowing us to spend 27h45 with bottlenose dolphins. The sighting frequency was of one group every 2h49. The median group size (4 individuals) was relatively small compared to other populations and would reflect the isolated and safe character of the bay. The habitat use of the bay was heterogeneous: some areas were more intensely used than others (representing 23 to 33% of the total surface occupied by the dolphins). Time-budgets indicate that dolphins spend most of their time traveling and diving. Differences among time-budgets were observed between summer and autumn. The observed behaviours were associated with environmental variables and differentiated one from another through several statistical analyses. Many similarities were highlighted between the feeding and the diving behaviours, underlining the fact that they could be two different strategies both aiming for one thing: to get food. Variables associated to resting behaviours indicated that the San Antonio Bay would be a safe place compared to other areas. The Kernel Density Estimation method is commonly used to visualize the most probable distribution of the sightings on a map. Here it was also used to geographically distinguish behaviours. Results show that they are not evenly distributed within the bay. Seen that bottlenose dolphins are more sensitive to anthropogenic disturbances while engaged in resting or socializing behaviours (Lusseau *et al.*, 2004; Lusseau, 2005), it would be crucial to take this into account in the prospective creation of protected areas in the future. If the results are confirmed by further studies and if the whole San Antonio Bay cannot be protected, this work indicates that at least the northern area should. Moreover, the KDE method seems to be an appropriate and advantageous tool when determining critical habitats and it would be worth using in other studies.

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Data from ship logger to onshore viewer

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The Belgian Marine Data Centre (BMDC, www.mumm.ac.be/datacentre) serves as national repository and processing centre for marine and environmental data, collected in the framework of national and international research and monitoring programmes. It ensures the data flow between data producers and end-users on a national and international level following international standards. The data cover most domains of oceanology as there are: physico-chemical measurements, optical properties of seawater, biodiversity, hydrodynamics, sedimentology, geology, geography and human interest. Most of the datasets relate to the Belgian Continental Shelf, the Scheldt estuary and its surrounding areas.

The integrated database on the quality of the marine environment contains the results of in situ measurements and observations and laboratory analyses of air, water, sediment and biota samples. Actually, historical data collected during the first phases of modern Belgian oceanography, Project Sea (1970-1976) and the Concerted Research Actions (1977-1982), are being digitized and imported. This will extend the range of time for which data is available, making it possible to perform long-term environmental change detection.

To disseminate high resolution data, the database is extended to refer to and document profiles, time series, trajectories… Also predictions of operational models at given locations are being processed for storage and for comparison with real measurements.
The BMDC is a node of the European SeaDataNet infrastructure (www.seadatanet.org), through which the data are made available on a European level in a standard way enabling the usage of common software packages like Ocean Data View (ODV).

As partner of the European project Geo-Seas, MUMM works on the archival of geological data according to international standards with regards to vocabularies and formats. This enables dissemination of data through the Geo-Seas portal (www.geoseas.eu) and usage of common tools, such as borehole viewers and interactive 3D seabed viewers.

During data processing, basic information on a measurement or gear deployment (e.g. location and time) often appeared to be missing or inaccurate. Unanticipated events or anomalies during acquisition are of importance for the subsequent processing and interpretation of marine data. In order to simplify the work for scientists onboard and data managers onshore, the data centre is also involved in the elaboration of a common software package used for logging events onboard, based on an ontology. This software, EARS (Eurofleets Automatic Reporting System) is produced in the frame of the European project Eurofleets (www.eurofleets.eu).

A detailed hydrodynamic model for the port of Zeebrugge: a numerical tool as part of an integral approach for accessibility and safety studies

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The port of Zeebrugge is the second largest harbour in Belgium, and the fastest growing of the region. To improve the accessibility of the port, a lot of efforts are already taken by the Flemish Government in deepening the navigation channel and outer port (CDNB). Thanks to these intensive dredging activities, ships with a draught up to sixteen meters can enter the port during eight to ten hours a day. However, due to its dimensions and high flood flows, the ship channel and the port entrance are characterised by high cross currents during high water, and safety is no longer guaranteed. Therefore, the inbound sailing window for large container ships and liquefied natural gas carriers (LNG) is restricted to a couple of hours a day.

Another threat which limits the cost efficient exploitation and the growth of the harbour is the high dredging cost. The whole Belgian coastal zone is characterised by high turbidity levels with a turbidity maximum reaching from the Scheldt Estuary till Oostende. Due to its geographical position, i.e. in the centre of the turbidity maximum, and its geometry and dimensions the outer port is subject to heavy siltation. The siltation of the port is mainly driven by the tidally driven water exchange through the port entrance.

In 2009 Flanders Hydraulics Research was commissioned by the Maritime Access Division (aMT) of the Department of Mobility and Public Works (MOW), to develop an integral approach for safety and accessibility assessments for the port of Zeebrugge. The goal of the project is to optimize the accessibility of the port in terms of extending the sailing window, and to minimize the dredging costs at the same time. The study is an integral approach of three major tools: detailed numerical models, a large physical model and simulation studies. With the integrated approach it should be possible to investigate the effects of possible future harbour extensions on the safety, accessibility and siltation of the harbor.

The objectives of the numerical model developed within the Delft3D model environment are four-fold:

- Accurate estimation of the cross-flow velocities in front of the harbour entrance and inside the outer harbour, both for the current situation as for potential harbour extensions and mitigation rules.
- Accurate description of the water exchange, as the primary driver for siltation.
- Provide the boundary conditions of the physical model.
- Provide accurate time dependent vector maps for simulator studies: this data is used by the simulator software to compute the forces acting on a manoeuvring ship during harbor approach and mooring.

Currently under development is the development of a transport model for fine sediments. This transport model will be used to assess the siltation in the harbour of Zeebrugge.

To stay or go: differential dispersal rates in cryptic species of a marine nematode

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Behind the morphological similarity of many species, a hidden genetic diversity can be found. This cryptic diversity has been well documented in the marine nematode *Rhabditis (Pellioditis) marina*, a common bactivore associated with decomposing macro-algae in the littoral zone of coastal and estuarine environments. Four cryptic species of *R. marina* (Pm I, Pm II, Pm III and Pm IV) co-occur along the south-western coast and estuaries of the Netherlands. This coexistence challenges traditional competition theory, which states that competition will be most severe between closely related species. A previous study showed that competition between the four cryptic species occurred, but interspecific interactions were affected by environmental conditions such as salinity. One of the most important mechanisms to react to competition is dispersal. Most organisms have at least one stage in which dispersal occurs over a specific spatial scale. Meiobenthic species, however, lack any pelagic stage. But, recent research shows more and more evidence that meiofauna is also able to actively disperse with lateral sinusoidal movements in the interstitial spaces as one of the most common modes of dispersal of nematodes over short distances.

Dispersal is a process triggered partially by the internal conditions of organisms and partially by environmental conditions. In the current experiment, species-specific differences in active dispersal rates and the effects of salinity and food distribution on dispersal behaviour were tested in four cryptic species of R. marina (Pm I, Pm II, Pm III and Pm IV). The results of the experiment showed that dispersal is a species-specific behaviour with Pm III being the most rapid disperser (first dispersal event occurred after an average of 3 days), and Pm I the slowest disperser (average of 10 days). An effect of food distribution on the dispersal rates of all cryptic species was found with the most rapid dispersal if no food was present at the start situation. Salinity also had an effect with a higher dispersal rate at lower salinity for all the species. Moreover, the number of dispersive organisms differed between the species, with only one female disperser in Pm I and Pm III and a mix of female and male dispersers for Pm II and Pm IV at the first dispersal event. This species-specific dispersal behaviour and the influence of external conditions on dispersal can influence the reaction on competition. In a future experiment the effect of competition on dispersal will be studied by using competition cultures, where all four cryptic species can influence each other, but the organisms have the chance to disperse away. These results are important to better understand the processes behind the coexistence of cryptic species.

Identifying commercial fish species and detection mislabeling using DNA barcoding

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In order to protect the consumer, the EU has strict regulations for seafood labeling, which must include the species name (EU Council Regulation No 104/2000, EU Commission Regulation No 2065/2001). However, commercial fish species available on the market cannot always be easily identified, especially when morphological characters have been removed in processed products (e.g. fish fillets). DNA barcoding, i.e. the sequencing of the mitochondrial reference marker gene cytochrome oxidase subunit 1 (CO1), can be used to identify species (Hebert *et al*., 2003). In order to identify processed fish products, DNA will be extracted from the samples and CO1 will be amplified by Polymerase Chain Reaction (PCR) with fish-specific primers (Kochzius *et al*., 2010) and sequenced. The sequences will be compared with the known sequences of voucher specimens available in sequence databases (e.g. Ward *et al*., 2009; Kochzius *et al*., 2010). For this aim, the program Mega5 (Molecular Evolutionary Genetic Analysis) will be used for analyzing the sequences. In this study, samples will be taken in fish shops, supermarkets and sushi take away restaurants in Brussels and other Belgian cities to evaluate if mislabeling and fraud occurs. There will be a focus on higher priced species, e.g. cod (*Gadus morhua*), sole (*Solea solea*) and tuna (*Thunnus spp*.). These species are more likely to be replaced by other, less valuable species as recent research in Dublin could show. About 25% of product from cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) appeared to be a different species like saithe (*Pollachius virens*) and Pollack (*Pollachius pollachius*). (Miller, 2010).

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Talking to the WoRMS: what can VLIZ web services do for you?

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Generally we would open our browser (Internet Explorer, Firefox, Chrome,…) if we would want to access information that is somewhere on the internet. However, things are rapidly evolving. Weather forecasts, real-time stock trading rates and news items appear on our mobile devices without any human interference. There are systems that allow the user to access information directly from within other applications. These systems are called web services.

Web services are systems that allow communication between two computers over the web. This communication is based on universally accepted standard protocols like HTTP (Hyper Text Transfer Protocol) , XML (Extensible Markup Language), SOAP (Simple Object Access Protocol),… Given the potential of these web services for providing support to its scientist costumers, VLIZ has set up a number of web services for accessing the available data and information resources.

A good example of these web services are the SOAP (Simple Object Access Protocol) WoRMS web services (http://www.marinespecies.org/aphia.php?p=webservice). The WoRMS web services allow users to consult the World Register of Marine Species (WoRMS) and perform taxonomic data quality control by matching their own species lists with a standard register of taxonomic names. This standard register is continuously being checked and updated by taxonomic experts from all over the world. Using the web service makes it possible for the user to access the most recent and up-to-date information.

Different web services have been defined for each of the operations that were considered useful:
- get the AphiaID for your taxon
- check the spelling of your taxa
- get the authority for your taxa
- get the full classification for your taxa
- resolve your unaccepted names to accepted ones
- get all synonyms for a taxon
- match your species list
- resolve a common name/vernacular to a scientific name
- get the common name(s)/vernacular(s) for a taxon
- get the sources/references for a taxon
- get the WoRMS citation for a taxon
- get the direct children for a taxon

The demo session demonstrates the applicability and added value of the WoRMS web services in Excel and R software.

Education through digital objects – practical examples from the EMBC Master Programme

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The 'World Conference on Marine Biodiversity in Aberdeen (2011)' (http://www.marine-biodiversity.org/) introduced the use of digital objects as an alternative for the classic paper based poster session. The Master Programme EMBC decided to introduce this new form of science communication in different teaching modules, in order to have the next generation of marine scientists ready to use these techniques.

During the EMBC summer school in Galway (Ireland) in July 2011, students were asked to make small documentary movies explaining to a broader public the work that was carried out. One of the teachers specialized in modern communication techniques, assisted the students in making these movie based digital objects. This exercise showed that by using very simple tools (cell phones, small digital cameras and a suite of freeware movie-editing tools) high quality products can be delivered.

Making movies is one of the commonly used techniques to build a digital object. However it was believed that students also need to learn the use of alternatives. The course 'Data and Information management', taught to first year EMBC students in Ghent and Faro (Portugal), includes now a specific module on the creation of digital objects. Students are introduced to different tools and techniques (ranging from classic powerpoints, to screen recordings, to the use of online animation tools), and present as an assignment a 3 minute long digital object about a 'Coastal and Marine Wiki' related topic (www.encora.eu/coastalwiki).

EMBC – Master of Science in Marine Biodiversity and Conservation

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The Erasmus Mundus Master of Science in Marine Biodiversity and Conservation (EMBC) is offered by a University consortium consisting of 6 partners: Ghent University (Belgium), University of Bremen (Germany), University of the Algarve (Portugal), University Pierre et Marie Curie - Paris 006 (France), University of Oviedo (Spain) and University of Klaipèda (Lithuania)).

The study programme is divided in 3 thematic modules: (1) Understanding the structure and function of marine biodiversity, (2) Toolbox for investigating marine biodiversity, (3) Conservation and Restoration of marine biodiversity.

Since the start in 2008, up to 200 students from over 40 countries have enrolled in this international Master Programme. The international dimension is not only reflected in the multinational origin of students but also in the mobility within the programme: Each student enrolling in EMBC has to study in at least two different universities. Many students study even in three different locations by doing thesis work in marine research institutes all over the world.

European students who still wish to enrol for the next academic year can still submit their details on the website – http://embc.marbef.org

MARES – Master of Science in Marine Biodiversity and Conservation

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MARES is a three-year world-class Joint Doctoral Programme offered by a consortium of 23 partner institutions (11 full partners and 12 associated members) originating from 14 countries.
Ghent University (Belgium) is the coordinator of MARES.

MARES doctoral candidates study in at least two of the partner institutions and are awarded a joint Ph.D. degree (Doctorate in Marine Sciences).

MARES focusses on six scientific fields, all dealing with the effects of impacts of humans on the natural marine environment:

- Future oceans: temperature changes - hypoxia - acidification
- Understanding biodiversity effects on the functioning of marine ecosystems
- Biological invasions
- Natural resources: overexploitation, fisheries and aquaculture
- Ocean noise pollution
- Habitat loss, urban development, coastal infrastructures and Marine Spatial Planning

The MARES consortium also offers a Joint Doctoral Training Programme (approved by 13 European universities).
Key elements of the training programme are:

- at least 24 Credits of training of which at least 10 Credits in transferable skills and at least 10 Credits in expert training courses
- attendance of at least two international scientific conferences (with poster or oral presentation),
- at least one publication accepted in a peer reviewed journal
- attend at least two 'MARES Annual Meetings'

Doctoral researchers who finish this training programme successfully are awarded a Joint MARES training certificate. More information can be found on the MARES website: http://www.mares-eu.org

Physiological effects of a marine algal toxin on a primary consumer: tales of the unexpected

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Harmful algal blooms can cause serious health risks and economic losses due to the production of toxins. Okadaic acid (OA), a marine toxin produced by different species of dinoflagellates including *Prorocentrum lima*, accumulates in filter feeding shellfish. OA is known to inhibit the protein phosphatase enzymes in humans consuming contaminated shellfish, resulting in the diarrheic shellfish poisoning syndrome. Although the physiological effects of OA on mammals are relatively well understood, this is not the case for the effects on their main vectors (i.e. shellfish).

In this study, the effects of OA on the lysosomal membrane stability (LMS) of the haemocytes and on the protein phosphatase (PPase) activity of the hepatopancreas in the mussel *Mytilus edulis* were studied. In a first phase the mussels were dissected and the enzymes of the hepatopancreas were exposed to okadaic acid in vitro (conc. up to 672µg $OA.g^{-1}$ hepatopancreas wet weight). This resulted in a significant reduction (4%) of the PPase activity, starting at a concentration of 26.2ng $OA.g^{-1}$ hepatopancreasWW, with a maximum inhibition of approximately 15% at 168ng.g^{-1} hepatopancreas WW and higher. In the second phase, the mussels were exposed in vivo to toxin producing algae (*P. lima*). Two concentrations were tested: 2.85µg $OA.l^{-1}$ (500 cells.ml^{-1}) and 9.55µg $OA.l^{-1}$ (1,500cells.ml^{-1}). Okadaic acid accumulated in the mussels' hepatopancreas with a mean concentration of 220ng.gWW^{-1} (500cells.ml^{-1}) and 740ng.gWW^{-1} (1,500cells.ml^{-1}). Based on the in vitro results a 15% reduction in PPase activity was expected. However, there was no significant reduction of the LMS or the PPase activity.

Two conclusions can be drawn from these results. First, in vitro there is a 15% reduction of the PPase activity this means that these enzymes are sensitive to OA exposure. Secondly, in vivo OA has no negative effect on the PPase activity or LMS. Apparently *M. edulis* is, at the concentrations tested, able to prevent the inhibition of protein phosphatase enzymes by OA.

Do windmill parks function as a refugium?

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Many countries are in the process of installing offshore windmill farms to comply with the European obligations to get 20% of their electricity consumption out of renewables by 2020. Two companies already exploit part of their wind farm in the Belgian part of the North Sea, located in a predefined offshore zone near the Dutch EEZ border. As part of the environmental impact monitoring, we investigate the effect of the wind farms on the soft-bottom epibenthic and demersal fish fauna.

The zones where windmills are being built, are located on heavily exposed offshore sandbanks and are naturally characterised by a relatively poor benthic and demersal fish fauna. At least during the first years of exploitation we don't expect spectacular changes in density of the soft-bottom fauna on the top of the sandbanks. However, other species are expected to become more abundant, (in)directly associated with the introduction of hard substrates (in casu the windmills). Secondly, we expect the windmill parks to serve as a refugium for several species, as commercial (bottom disturbing) fishing activities are prohibited inside the parks.

Since December 2010, 55 windmills are operational in the Belwind concession zone (phase-I, 17 km²) on the Bligh Bank. On 22 September 2011, we got the first permission to operate an 8m-shrimp trawl between these monopiles from the RV Belgica. Preliminary results indicated the presence of several large individuals (>40 cm) of plaice (*Pleuronectes platessa*), turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*) inside the windmill park. Similar large-sized individuals of these flatfish species were not caught outside the windmill park on that day. Also during previous monitoring campaigns, no such large individuals were caught, neither in the windmill park (before construction) nor outside the windmill park. Several big plaice were again observed during diving operations in the Belwind park on 22-23 November 2011, for the first time since that type of monitoring started. A plausible explanation is that organisms have a higher chance to survive and to grow bigger inside the windmill parks as fishermen cannot catch them there (fishing not allowed, confirmed by VMS data). However, not only the absence of fishing activities seems to favour soft-bottom species. Small-scale and less-exposed sandy habitats are formed between the rocks and stones that are used to protect the windmills. These may provide perfect refugia for soft-bottom benthic species.

Also, epibenthic species may profit from the introduction of offshore windmill farms. For example, much higher densities of the green sea urchin (*Psammechinus miliaris*) were found in the gullies inside the Belwind park compared to the gullies in the reference area. Again, this is probably correlated with the absence of fishing activities (and the associated bottom disturbance) in the windmill concession zones, in combination with the presence of coarse sediments around the windmills, which is the favourable habitat for green sea urchins.

These preliminary results might indicate that windmill parks can function as a refugium for demersal fish and epibenthic fauna. Of course, further monitoring and targeted research actions are needed to confirm this hypothesis.

Evaluation of the impact of electro shrimp trawl fishery

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Brown shrimps are caught with bottom trawls, as is the case for 90% of all demersal fish, shell and crustacean landings in the North Sea. These demersal trawl fisheries are known to produce large amounts of discards and to disturb the seafloor habitat of benthic organisms. This results in severe ecosystem damage and the indirect reduction of quota in other fisheries. Furthermore fuel consumption is high. In order to increase the sustainability of these fisheries and consider ecological certification,technical adaptations are necessary to avoid these problems. Electric pulse fields have proven to be the most promising option for alternative stimulation in fishing gear, replacing the mechanical stimulation.

Since 2008 the Belgian ILVO research institute has been successfully testing their Hovercran electro pulse trawl for brown shrimp fishery. In this device the heavy bobbin rope is replaced by light weight electrodes creating a low-intensity electric fieldwhich selectively induces a startle response in the shrimps. Other benthic organisms are left untouched and can escape underneath the hovering trawl that collects the jumping shrimpswithout disturbing the seabed (Verschueren *et al.*, 2009).

Nevertheless, the effects of suchlike electric pulse field on marine organisms are largely unknown (Snyder, 2003). Preliminary exposure and survival experimentsindicated that the use of this low frequency pulse has no immediate significant effects on most adult fish and invertebrate species (Vercauteren *et al.*, 2010). However, electro sensitive fish, like sharks and rays, and polychaete species, which have a key role in the benthic ecosystem, were not included in these studies. Additionally, the influence on different life stages has never before been investigated. Electrofishing over active spawning grounds may affect survival of embryos, larvae or juveniles if exposed during their more sensitive stages (Bohl *et al.*, 2010). Further research to fill these gaps in knowledge hence is crucial to revalue pulse fishing and to provide information enabling to lift the standing ban on electric fishing in the EU.

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Patterns and prevalence of marine fish diseases and parasites

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Prevalence data of fish diseases and parasitic infections on wild marine fish were collected on the Belgian Part of the North Sea during the years 1996-2011. The assessment of prevalence focused on externally visible diseases and parasites of the body, skin, gill and fins. In addition to the externally visible diseases, tissue related diseases were evaluated. Therefore, livers were excised and inspected for the occurrence of visible tumours and other external diseases. The assessment of fish diseases was based on guidelines recommended by ICES (Bucke *et al.*, 1996).

In accordance with other national and international monitoring programmes, the wild marine flatfish dab (*Limanda limanda*) was used as sentinel species as it is sediment-inhabiting and abundant. In our study, biological effect monitoring of fish diseases was extended to the pelagic round fish species whiting (*Merlangius merlangus*). Dab and whiting were caught during sampling campaigns with the RV Belgica, using standardised fishing methods. Both species were sampled at different locations of the Belgian Part of the North Sea and pooled into two areas: coastal and offshore area. For dab, this study mainly focused on the prevalence of epidermal papilloma, *Glugea sp.*, *Acanthochondria sp.*, *Stephanostomum sp.*, whereas for whiting the occurrence of *Cryptocotyle sp.*, *Clavella sp.*, *Lernaeocera sp.* was investigated.

Long-term data on fish diseases are used to detect prevalence trends, which can be applied as an indicator for the marine environmental health status. As it is problematic to define background levels or environmental assessment criteria for the examination of fish diseases, long-term prevalence data could be implemented as a guideline. Long-term prevalence data of parasitic infections showed undulating prevalence patterns over the years.

In the present study, temporal and spatial patterns of disease prevalence were quantified during the period 1996-2011, as well as the investigation of possible relationships of fish diseases with the levels of environmental contaminants. Along the Belgian Part of the North Sea, mainly parasitic infections were observed. More severe diseases showed a significant decrease during the last decade.

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Vegetation structure at Zhanjiang Mangrove National Nature Reserve (ZMNNR), P.R. China: comparison between original and non-original trees using ground-truth, remote sensing and GIS techniques

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In order to determine the areas best suitable for future genetic differentiation works at Zhanjiang Mangrove National Nature Reserve (China), the present methodological study has attempted to define a step-wise procedure to distinguish mangrove trees present before planting schemes (**Om** areas) from trees which were planted, as well as, trees that have naturally established after interaction between planted and non-planted trees (*e.g.,* through pollination) (**NOm** areas). Subsequently, Corona satellite (mono-band) image from 1967 and a high resolution GeoEye-1 (multi-spectral) image from 2009 digitized mangrove cover areas were overlapped to detect *a priori* ground inventory which consisted in selecting 5x5m plots from 1967 vegetative areas (**Om)** and the remaining forest in 2009 (**NOm**). In each plot, the tree structural parameters such as density (ind.ha^{-1}), basal area (m^2.ha^{-1}), height (m), and Complexity Index (CI), were estimated for validating the differences between **Om** and **Nom** stands. The data were analyzed through Bray-Curtis similarity and non-metric Multi-dimensional Scaling plots in PRIMER *v*6. It was possible to identify 3 groups from each hierarchical clustering of the above vegetation indicators (similarity percentages: for density 45%, basal area 25%, and height 65%). The species' distributional patterns have indicated that **Om** areas are in a state of maturity (total density, 1,868 - 9,327 ind.ha^{-1} and total basal area, 0.83 - 1.252 m².ha^{-1}), and representing characteristics of less disturbed forest. Similarly, high CI values were obtained from **Om** stands**.** In addition, the sequential satellite imageries (1967-1971-2000-2009) revealed an increase of 347% in mangrove cover dominated by *Aegiceras corniculatum* (42.4%). Overall, the results suggest that the methodology is straight forward for distinguishing **Om** stands from and **Nom** stands, whereby dominant or bimodal species are categorized by their differences in height. Finally, the advantages and limitations of this methodology were highlighted, along with some recommendations for future genetic studies at ZMNNR.

Very high SPM concentrations in the southern Bight of the North Sea detected from space

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The dynamics of suspended particulate matter (SPM) control processes such as sediment transport, deposition, resuspension, primary production and the functioning of benthic communities. Improving our understanding of SPM concentration variability in nearshore areas, where the SPM concentration is particularly high, is essential to assess the human footprint on this environment and to develop sustainable socio-economic activities in parallel with marine environmental protection. SPM concentration varies strongly in the Belgian coastal area. Very high SPM concentrations occur during high energetic conditions, such as storm periods. These high SPM concentration are well known from in situ measurements (Fettweis *et al.*, 2010) but are rarely captured by satellites as the sky is then often covered by clouds. Shortcomings remain for in situ and remote sensing measurements. Satellite imagery suffer from a low temporal resolution, are only related to surface data and are biased towards good weather condition and spring-summer seasons; whilst in situ measurements have a limited spatial resolution (Fettweis and Nechad, 2011).

Good satellite images during stormy periods are therefore very important sources of information, as they reveal the geographical extension of the turbidity maximum zone. For 2011 two events with clear sky and high hydrodynamic forcings have been selected to investigate spatial extension of the high turbidity zone. The first was during spring equinox (21 March), which coincided with full moon resulting in an exceptional high tidal range and consequently very high currents. During this period wind forcing was very low. The second occurred during a storm period on 13 December. On both occasions in situ measurements from a tripod situated in the turbidity maximum area are available.

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Expanding the economic lifespan of $PSPC_{15}$ from 15 to 25 years by means of on board restorations

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Corrosion is an electrochemical process in which electrons are transferred between two parts of a metallic surface with a different potential. For corrosion to occur the presence of an electrolyte is necessary. At the cathode the excess of electrons is used to create hydroxide ions. ($O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$) . To replenish the electron supply material will be sacrificed at the anode ($Fe \rightarrow Fe^{2+} + 2e^-$). In the electrolyte the hydroxide- and the metal ions will join and create a brown substance called rust.

All seagoing vessels do rust. To prevent this corrosion, a number of possible solutions exist. One of them is applying a coating to the metal structure of the ship to create a barrier between the electrolyte and the metal.
Unfortunately no coating is perfect and damage will occur sooner or later. These small defects can be disastrous for the substrate. The damaged part becomes anodic and the intact part of the structure cathodic. Due to the difference in surface huge quantities of electrons will have to be furnished by a relatively small section. Consequently the corrosion process is concentrated around the failure in the coating and the degradation will proceed at an increased rate. This will lead to very local but severe damages of the metal.

$PSPC_{15}$ is an epoxy coating system that offers at least 15 years of protection if correctly applied and maintained on a well prepared surface in acceptable conditions. Due to the commercial operation of the ship damages to the tank coating cannot be excluded. Up till now, the restoration of an epoxy coating in ballast tanks, was impracticable with the on board resources. The repairs were postponed the next dry-dock visit, usually 2 times every 5 years. The worst case scenario is that the local corrosion process proceeds undisturbed for 3 years at a very high rate. Important, very expensive, steel replacements may become necessary much earlier than normal. The economic lifespan of a ship is 25 years. In case of an inadequate maintenance program of the ballast tank coating this may be put at risk.

The purpose of this research program is to develop a feasible technique to repair small coating damages following an external impact.
Driving idea is that the repair can be done by the crew without compromising the commercial activities of the ship. The surface tolerance and ease of application of the paint are key-elements of this maintenance philosophy.

This idea can result in another attractive possibility. At this moment $PSPC_{15}$ offers 15 years guarantee to keep a coating in a “good” condition. Maybe, by providing an easy repair technique this period can be stretched to 25 years, being the economical lifespan of the average merchant ship.

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Oxygen, an algae growth inhibitor in the historical Schelde?

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Recent years have shown a remarkable increase of primary production in the tidal freshwater part of the Schelde Estuary (Cox *et al*., 2009). Light climate has been considered as major limiting factor in many estuaries (Desmit *et al*., 2005; Gameiro *et al*., 2011). However, light climate in the Schelde has not changed significantly since 1970 up till now (Omes reports). Nutrients and allochthoneous organic matter input on the other hand have clearly decreased with increasing water treatment efforts (Van Damme *et al*., 2005; Soetaert *et al*., 2006). A lowered phytoplankton production was actually expected from these efforts, however the opposite has shown to be true (Cox *et al*., 2009). Thereby, also a shift to morphologically larger diatoms is observed (personal comment Els Van Durm 2011, UGent). A mathematical model has shown the existence of two alterative stable states in the tidal freshwater of the Schelde of low and high phytoplankton biomass, with high and low ammonia concentrations respectively. Historical phytoplankton production could have been inhibited by low oxygen concentration and/or toxic substances in such a hypoxic/anoxic environment (e.g. ammonia, water sulphide) (Cox *et al*., 2009). Up till now the effect of multiple stressors on phytoplankton production is still not fully understood (Cloern, 2001).

To understand the effect of hypoxic/anoxic environments, an algae inhibition test is performed, whereby oxygen concentrations in the growth medium are reduced by continuous flowthrough of nitrogen. In a first step, green algae (*Pseudokirchnierella subcapitata*) are used, wherefore growth conditions are well known from previous experiments. Preliminary results already show a decline in algal growth. However, the experiment is still in its start phase. This poster wants to show further results on the process of this experiment. In a next step, diatoms will be used and tests for multiple stressors will be performed (hypoxy/anoxy combined with changes in light climate). A better understanding of multiple stressors, will eventually lead to a better understanding of also future evolution of the Schelde Estuary towards a possibly new trophic equilibrium.

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Reduced seed set by root herbivory in a coastal dune plant: are pollinators involved?

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Herbivory is often one of the most important environmental factors affecting plant fitness. Because herbivores deplete resource reserves in plants, there may be fewer resources left to invest in reproductive output and/or in pollinator attractive features.

Our study system involves *Cynoglossum officinale*, a monocarpic perennial dune plant which is often subject to root herbivory by the specialist beetle *Mogulones cruciger*. The larvae of this beetle develop in the roots and feed on root tissue. This larval infestation was found to have a negative effect on the seed set of *C. officinale*. However, it is not clear whether there is only a direct cause to this negative effect: through a lower resource allocation to seed production, or whether there is also an indirect cause: through reduced pollination success due to lower resource allocation to pollinator attraction. In this experiment we investigated whether pollinator attractiveness of *C. officinale* plants is affected by this root herbivory and whether this may have an impact on the reproductive output.

After subjecting study plants to different herbivore pressures in the lab, we measured several plant traits. At the VLIZ research station in Wenduine we observed natural pollinator visitation and assessed pollen limitation through supplemental hand pollinations. Plants were harvested after flowering and then seed set and root damage were quantified.

In this experiment root herbivory also turned out to have a negative impact on seed set. Moreover, we found that pollinator visitation rate decreased and pollen limitation increased with increasing root damage. Consequently, the results of this experiment indicate that pollination is involved in the reduced seed set caused by root herbivory.

Scheldemonitor, the online data- and information system on research and monitoring of the Scheldt Estuary

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The Scheldt Estuary has been and still is the object of study in numerous fundamental and applied scientific studies. It is a unique tidal ecosystem that provides a lot of services to economy, society and nature. In the framework of the common Flemish-Dutch long-term vision of the Scheldt Estuary, a portal was set up to centralise information, data and data products. Since 2004 the VLIZ has been assigned the task to set up this portal by the Flemish and Dutch government. Since 2011 the governments are represented by the Flemish-Dutch Scheldt Commission (VNSC) as sponsor of the ScheldeMonitor that now will act as a supporting system on the T2009 evaluation of the Scheldt Estuary.

ScheldeMonitor is an online accessible data- and information system for research and monitoring regarding the Scheldt Estuary. The database consists of a considerable amount of information that is gradually increasing. Five modules were set up to identify the main players (*Persons*, *Institutes*), research activities (*Projects/Datasets*) and literature (*Publications*). For each of the modules, a thematic and advanced search facility ensures an efficient retrieval of the required information.

In search for measurements? Through the ScheldeMonitor data portal you have access to data from different sources and research activities. You can download publicly available datasets or make a more refined selection on time, place and data provider. An easy to use interface will guide you through your request. Data is visualised on a map to support your search. The data portal is set up to centralise data. Data is stored if they are not easily accessible. But where existing online data systems and data transfer systems are adequately developed, it is sufficient redirecting to these systems.

The ScheldeMonitor hosts a set of 18 indicators. They largely fit into the three main themes on safety, naturalness and accessibility and could easily be embedded in the structure of ScheldeMonitor. Indicators are increasingly used as a tool for reconnaissance, planning, implementation and evaluation of policies. They are very useful as a link between policy and research.

This portal is available at http://www.scheldemonitor.org; http://www.scheldemonitor.be; http://www.scheldemonitor.nl.

OMA - The Open Marine Archive: coming of age

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Since the end of 2005, the Open Marine Archive OMA is the central repository for all digitally available publications from Belgian marine researchers. The purpose of this online collection is to give immediate, complete, and permanent access to all the published results of Belgian marine research. We have reported a first time in 2008 (Haspeslagh *et al*., 2008), and since then, a steady growth in content over the years* illustrates the continued commitment of our community to this initiative, and the support for open access to their scientific output.

The OMA repository is indexed and distributed by various so-called harvesters (web-based tools that search and retrieve specific open-access content on the internet), of which the most important one is Google Scholar. The result of this harvesting is that references to online available publications are almost always found in the top-10 result list of a typical search action in Google, the most widely used search engine today. In this way, Belgian marine research receives extremely important extra exposure on the web.

Although OMA seems to be a success story so far, much work still lies ahead of us. Solving copyright issues, dealing with publishers' policies on open access, informing the researcher on all open-access topics, and digitizing the historical body of Belgian marine scientific literature are the main focal points for the near future. The ultimate goal is to make OMA the flag ship of information on the Belgian marine community.

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* Since 2005, the mean growth of the OMA-repository has been 941 records per year. At the end of 2011, the total number of OMA-records was 9893 (including 3000 records of retrospective pre-2005 input).

Risk assessment of non-indigenous marine invaders: a combined approach of morphological and molecular analysis allowed unambiguous identification of the comb jelly *Mnemiopsis leidyi* in the Belgian Part of the North Sea (BPNS)

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Mnemiopsis leidyi is an invasive American species present for more than two decades in European waters. This species has reportedly influenced the collapse of stressed environments and commercial fish stocks. Some native species are morphologically very similar to *M. leidyi*, which hinders identification of this ctenophore in newly invaded areas. Risk assessment of non-indigenous marine invaders can only be successful if identification is unambiguous and a combination of morphological and molecular analysis can be of great assistance. For this purpose different fixatives have been tested and scored on their ability to preserve morphological features and to allow extraction of DNA with high concentration and purity. Fixated samples of *M. leidyi* were observed microscopically and the extracted DNA was tested with primers for the nuclear internally transcribed spacer (ITS) region and the mitochondrial cytochrome b (CYTB) and cytochrome oxidase I (COI) region. The results of the molecular analysis were furthermore used to prepare a species specific DNA probe and primers to allow identification of *M. leidyi* in fish stomachs. This makes it a useful method to study prey–predator relationships which in turn can help in a better management of this notorious invader.

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Connectivity of *Amphiprion akallopisos* (skunk anemone fish) in the Indian Ocean

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The dispersal of the skunk anemone fish (*Amphiprion akallopisos*) is limited to the larval stage, because during their adult life these tropical fish live in symbiosis with sea anemones and do not migrate. The species has a disjunct distribution with subpopulations in the eastern and the western part of the Indian Ocean. Larval dispersal enables anemone fishes like *A. akallopisos* to disperse over long distances. Genetic studies, as well as studies on defensive behaviour and colour pattern, have shown that considerable regional intra species variety exists in the genus *Amphiprion*, notwithstanding the species' capacity of long distance dispersal through pelagic larvae. The goal of this master thesis is to examine the connectivity between the eastern and the western subpopulations of *A. akallopisos* as well as connectivity on a smaller scale, within these subpopulations, studying the genetic population structure. DNA will be extracted from fin clips of specimens from different parts of the Indian Ocean. Mitochondrial DNA (control region) will be amplified using Polymerase Chain Reaction and sequenced. From these sequences, a haplotype network will be made and an Analysis of Molecular Variances (AMOVA) will be conducted, which permit to interpret geographical connectivity within this species. The study contributes to a better understanding of coral reef connectivity and tropical fish species distribution and dispersal. It also serves management purposes by providing useful information for the management of Marine Protected Areas.

Reconstruction of the long-term satellite-derived sea surface temperature including error maps in the South China Sea

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The AVHRR (Advanced Very High Resolution Radiometer) sea surface temperature is very useful for researches in oceanography because of its high resolution. An AVHRR limitation is the high missing data percentage due to cloud coverage. In the South China Sea, the average missing data is usually more than 80%, especially more than 95% in the regions near the Borneo Island. In this study, we use DINEOF tool (Data INterpolating Empirical Orthogonal Functions) to reconstruct a daily night-time AVHRR data set with horizontal resolution of 4km spanning from 1990 to 2009. Error maps for the reconstructed sea surface temperature are also calculated. Besides, a comparison between the result and in situ data is implemented. From the long-term reconstructed data, we can monitor the inter-annual variability of circulation, eddies and upwelling. The EOF analysis shows that the first three modes explain about 95% of seasonal variability.

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Unravelling the light-dependent cell cycle onset in diatoms

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Despite the enormous importance of diatoms in aquatic ecosystems and their broad industrial potential, little is known about their life cycle control. Diatoms typically inhabit rapidly changing and unstable environments, suggesting that cell cycle regulation in diatoms must have evolved to adequately integrate various environmental signals.

From the first genome analyses of *Thalassiosira pseudonana* (Armbrust *et al.*, 2007) and *Phaeodactylum tricornutum* (Bowler *et al.*, 2008), it became clear that the cyclin family in diatoms represents an expanded gene family. By comparative analysis of cyclin abundance among several closely related Chromalveolate species, this expansion was found to be specific to diatoms. In addition, phylogenetic analysis of the cyclin gene family lead to the discovery of a novel type of cyclins, the diatom-specific cyclins (dsCYCs) (Huysman *et al.*, 2010). Their early expression during the cell cycle, and the induction of several members upon changing nutrient or light conditions, hints at a role for the *dsCYCs* in transduction of the environmental status of the cell to the cell cycle machinery. Related to this, a crucial role in regulating cell cycle onset upon light exposure was found for one of these *dsCYCs* (*dsCYC2*). This cyclin was found as one of the first cell cycle genes expressed upon release by illumination of dark-arrested cells (Huysman *et al.*, 2010). In addition, silencing of *dsCYC2* interferes with normal cell cycle progression, suggesting that it is crucial to the control of the light-dependent G1-checkpoint in diatoms. The light-regulated transcription of *dsCYC2* and control of cell cycle onset is further demonstrated by its specific response to various spectral qualities (white, blue and red light) at different light intensities.

The results that will be presented here give more insights into the molecular mechanisms that tightly regulate the onset of the cell cycle machinery upon light exposure. They will contribute to our understanding of how diatoms succeed to respond adequately and rapidly to changing light conditions and will help to explain how diatoms gained this competitive advantage over other marine phototrophs during evolution. From an economic perspective the results will be useful for studies that aim to optimize diatom and algal cultivation techniques for industrial applications.

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Buffer capacity of the coelomic fluid in echinoderms

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The increase in atmospheric CO_2 due to anthropic activities results in an acidification of the surface waters of the oceans. The impact of these chemical changes differs according to the considered organisms. The intertidal rocky shores may harbor organisms pre-adapted to the upcoming changes as they already face tidal pH and temperature fluctuations. In order to cope with the changes in seawater pH, these organisms possess different mechanisms involved in acid-base regulation. Some organisms present a higher buffer capacity than seawater, among which echinoderms. The properties of this buffer capacity and the factors influencing it were investigated in the sea urchin *Paracentrotus lividus* and in the starfish *Asterias rubens*, both species occurring in the intertidal zone of the North Atlantic and the North Sea, respectively. Buffer capacity is partly due to the coelomocytes present in the coelomic fluid and, in *P. lividus*, it is also due to a compound which contributes to a higher buffer capacity of the coelomic fluid of this species compared to that of the starfish. The effect of a decreased seawater pH (in the scope of predicted future ocean acidification) on this buffer capacity in *P. lividus* was investigated. A gradual increase of the buffer capacity was recorded when the seawater pH was decreased. Moreover, the comparison of different echinoderm species showed that Euechinoidea present a very high buffer capacity while Cidadroidea (other sea urchins), starfish and holothurians have a lower one. This can be explained either by the presence of the compound only in Euechinoidea, linked to differences in the respiratory machinery, or by metabolic differences between the various classes of echinoderms.

Keywords: ocean acidification; echinoderms; acid-base regulation.

Heterogeneous flocculation combining the biological and mineralogical populations in a marine and coastal environment: literature study for a conceptual model

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The biological population dynamics (e.g. algae bloom) have been concerns of biologists and ecologists, whereas the sediment dynamics have been interest of geologists and hydraulic engineers, in a marine and coastal environment. The biological and mineralogical populations seem separate in different fields of study. Recent studies however have found that heterogeneous flocculation can integrate both the seemingly separate populations for combining the biological and mineralogical populations in a bio-mineral floc. Therefore, the literature study was aimed to investigate heterogeneous flocculation, in which the biological and mineralogical populations are the heterogeneous fractions for building a bio-mineral floc. The following are the important findings from the literature study. (1) The biological population exudes sticky extracellular polymeric substances (EPS) and transparent exopolymeric substances (TEP) which can bind biological and mineralogical particles together in a bio-mineral floc (e.g. Passow, 2002). (2) The amount of EPS and TEP depends on the competitive microbial population dynamics between phytoplankton, zooplankton and bacterioplankton in a marine and coastal environment and consequently determines the stickiness (i.e. flocculation capability) of biological and mineralogical particles (e.g. Jackson and Checkly, 2011). (3) The biological population finally becomes a less-dense amorphous part in a floc and affects the size and morphology of bio-mineral flocs, but the mineralogical population provides ballasts in a floc and determines floc density and settling velocity (e.g. Droppo, 2001; Ploug *et al.*, 2008). In fact, the biological and mineralogical populations attach each other and build a bio-mineral floc with the medium of EPS and TEP, due to heterogeneous flocculation in a marine and coastal environment. Further, the mineralogical composition is heterogenous and may change according to hydrodynamic conditions and seasons. Finally the conceptual model of heterogeneous flocculation in this literature study will be refined and simplified for developing the mathematical model, based on the TCPBE model of Lee *et al.* (2011)

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Long term beach nourishment impacts in interaction with environmental factors on the abundance of four dominant intertidal macro invertebrate species

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Coastal squeeze is the largest threat for sandy coastal areas. To mitigate seaward threats erosion and sea level rise , sand nourishments are commonly applied. However, its long term consequences on the macro invertebrate fauna critical to most ecosystem services of sandy coasts are still unknown. Seventeen sandy beaches nourished and controls were sampled in a chronosequential manner to investigate the abundance of four dominant macro fauna species and their relations with time since nourishment and relevant coastal environmental variables. Nourishments and environmental variables together explained the recovery of *S. squamata*, *H. arenarius* and *B. sarsi*. For *E. pulchra*, no environmental variable explained its abundance. Recovery took place within a year after nourishment. *S. squamata* even profited from the nourishments with increasing abundances after nourishment, taking into account its latitudinal gradient on the Dutch beaches. This confirms its role as an opportunistic species, therewith altering the initial community structure on a beach after nourishment. Beach nourishments do thus not seem to have long term negative consequences for the abundance of the four species. Responses to nourishments and environmental variables were species specific. This shows the importance of knowing the autecology of the sandy beach macro invertebrate fauna in order to be able to mitigate the effects of a beach nourishment and other environmental impacts.

Indicators for the Scheldt Estuary

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Policy and management of the Scheldt Estuary are a transnational issue which concerns both Flanders and the Netherlands. Since the end of the last century, Flanders and the Netherlands aim to adjust their policies and ideas as much as possible. This resulted in 2001 in the Long-Term Vision (LTV) of the Scheldt Estuary (Directie Zeeland AWZ, 2001) which was drafted by the Technical Scheldt Commission. An important part of the LTV is the 'Target 2030' ('Streefbeeld 2030') which, by 2030, aims for a healthy and multifunctional Scheldt Estuary, used in a sustainable way for human needs. The strategy to be followed in order to achieve the 'Target 2030' is written down in the 'outlines of development' of the Scheldt 2010.

In order to evaluate and support policies, it was decided to start up, within the framework of the LTV, a joint research and monitoring program which is known as the 'working group on research and monitoring' (WG O&M). One of the tasks which were performed in this group is the development of a set of indicators in order to provide a concrete content for the development of the Scheldt Estuary (Lescrauwaet *et al.*, 2009).
This project aimed to compile the latter set of indicators for the Scheldt Estuary based on facts and figures: policy-relevant indicators which are scientifically underpinned, quality-controlled data and a correct citation of the source (authors, data managers) and methodology. A number of strategic and specific objectives were envisaged (Lescrauwaet *et al.*, 2009):

Strategic objectives

- Gaining understanding of cause-effect relationships for advising policy makers and managers.
- Situating gaps in our knowledge and providing direction for future research within the LTV Research and Monitoring program.
- Establishing an educational and outreach function, in order to clarify the ecological and socio-economic functioning of the system and to be able to communicate about the boundary conditions.

Specific objectives

- Selecting, developing and visualizing a set of indicators that has an impact on, or is characteristic for an integrated vision on the safety, nature and accessibility of the system, as well as for fishery and recreation and tourism. This also means that the comparability of the measurements and analysis-methodologies and the differences in the standard specifications between Flanders and the Netherlands are accounted for.
- Updating the SchpeldeMonitor, in addition to the data portal, as a portal site for the Scheldt Estuary.

In total, a set of 18 indicators was selected for the Scheldt Estuary. Each indicator was reported according to a fixed pattern: Key message, Why monitor this indicator?, What does the indicator show? Where do the data come from?, Opportunities and threats and, finally, integration with other indicators/measurements. Furthermore, technical sheets with specifications of the measurements of the indicator with metadata were supplied. The Scheldt indicators are embedded in the site of the SchpeldeMonitor (http://www.scheldemonitor.be/indicatoren.php), where they are offered in combination with an information system (a data portal containing all metadata about projects, institutions, datasets, researchers ...).

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Storm surge prediction in the Belgian coastal zone

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The water level in the southern part of the North Sea and in the Scheldt Estuary are composed of the astronomical tide and an atmospherically induced surge. These water levels can be accurately simulated with a combination of hydrodynamic shallow water models and atmospheric data. The hydrodynamic modeling train of CSMv5 (Continental Shelf Model) and ZUNOv3 (ZUidelijke NOordzeemodel) (RWS-Waterdienst & Deltares) translates the astronomic water levels at the boundaries of the continental shelf to the Belgian coast while calculating the surge generated by meteorological conditions.
Flanders Hydraulics has a hindcast modeling train installed for research purposes and a forecast modeling train coupled with inland river models for prediction purposes. Both modeling trains run on the parallelized SIMONA WAQUA shallow water software (SIMONA 2009). CSMv5 has a Cartesian grid in spherical coordinates with a resolution of 1/8° longitude (9.3-6.5km) and 1/12° latitude (9.25km). The astronomical boundary conditions consist of the 11 main tidal components. ZUNO has a curvilinear grid with a resolution of 1-4km in the Belgian coastal zone. The models are linked with water level boundaries.
A hindcast validation analysis is performed to investigate the performance of the models, compared to one year of water level measurements (Belgium, France, Netherlands, UK) (Leyssen, 2011a). The influence of the wind on the surge level is investigated during a sensitivity analysis (Leyssen, 2011b).
Wind speed, wind direction and fetch length and atmospheric pressure are the three main causes for a surge in front of the Belgian coast. Theoretically a static windspeed of 30ms^{-1} (11beaufort) can create a surge level of over 2.5m if it has a fetch length of 200km (Leyssen, 2011b). So an atmospheric depression above the North Sea can create a substantial increase in water level in front of the Belgian coast. This water level rise does not include the waves associated with such an event.
The propagation of the tidal waves from the continental shelf to the Belgian coast is investigated using harmonic analysis of simulation results and measurements. A good agreement is obtained for both amplitude and phase of the major tidal components.
The hindcast shows that water levels can be predicted with an accuracy between 0.1m and 0.2m in the Belgian coastal zone, both for calm and stormy periods.
The relevance of this work is reflected in the operational hydrodynamic forecasting system that runs at Flanders Hydraulics. This system consists of a nested train of SIMONA models, starting with the CSMv5 and ZUNOv3 models and further refining into Kuststrook and Kustzuid models (RWS-Waterdienst & Deltares). The predictions use atmospheric forecasts from HIRLAM and ECMWF. Data assimilation techniques are applied to ameliorate prediction quality based on observations. Forecasts are produced every six hours.
From the most detailed models, water and surge levels and current data for the Belgian and Dutch coastal zone and the Scheldt River are extracted and forwarded to the Hydrologic Information Center (Flanders Hydraulics) and Oceanographic Meteorological Station (Coastal Division) to be used in e.g. flood and storm warning systems.

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Bioaccumulation of cadmium and lead in scallop *Argopecten purpuratus* (Lamarck, 1819) in bottom culture, at Sechura Bay

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In Sechura Bay, Peru bottom culture of the scallop *Argopecten purpuratus* is an important economic activity with a production around 69 millions dollars in 2010(Superintendencia de Administración Nacional Tributaria, 2010). However due to the nearby presence of cities, fishery industries, fishing piers and oil companies, this production area is subject to pollution and heavy metals are a concern(IMARPE 2007; INEI, 2008; ITP, 2008ab). Therefore, the bioaccumulation of cadmium and lead in *Argopecten purpuratus* was determined, as well as its variation with the size of individuals (50 - 65 and 70 - 80mm) and its relationship with the concentration of Cd and Pb in water and sediment and some abiotic variables during January to April 2010 at Sechura Bay was established. The evaluation was performed in-situ, where 1,700 specimens (50-65mm / 70-80mm) were extracted by semi-autonomous diving for planting randomly at a density of 10ind.m-2. Samples of 500 individuals were collected monthly for biometric and heavy metals analysis. Additionally, samples of seawater and sediment were collected with Niskin Bottle and plastic spatula respectively. Measurements of temperature, dissolved oxygen, electrical conductivity and redox potential were performed with the Multi-parameter HACH®. Both size ranges showed similar concentrations in the bioaccumulation of cadmium in muscle adductor and lead in gonad. The lowest tissue Cd concentrations were observed in the adductor muscle. Results showed significant differences ($\alpha < 0.05$) in Cd and Pb concentrations in adductor muscle and gonad in relation to size. The bioaccumulation of Cd in gonads of individuals from 50 to 65mm showed an increasing trend throughout the evaluation period, while individuals 70 to 80mm showed more variability. Pb always exhibited considerable variability. There were no significant correlations ($\alpha < 0.05$) between the bioaccumulation of Cd and Pb in scallops and the concentration of Cd and Pb in bottom sediments. The abiotic variables, temperature and salinity were directly related with the bioaccumulation of Cd and Pb in *Argopecten purpuratus*. Although traces of cadmium and lead are present we conclude that the values in edible tissue of scallop are below the maximum levels of the European Union (EU) and World Health Organization (WHO).

Keywords: *Argopecten purpuratus*; bioaccumulation; Sechura Bay.

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Modelling the chemical speciation of trace metals in surface waters of the river Zenne

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Trace metal speciation in aquatic environments is inherently complex due to the large number of possible interactions of the metal with dissolved and particulate components. However, adsorption on solid surfaces and formation of metal-ligand complexes plays important roles in controlling metal fate and behaviour. These reactions for example modify the bioavailability, and hence toxicity of the metal towards biota. Speciation study provides information on potential metal bioavailability under various environmental conditions and, therefore, may support environmental management decisions. However, no single analytical method can provide a detailed description of all the species involved, but will measure a certain proportion of the total complexes (Sigg *et al.*, 2006). The objective of this study is to describe and understand the metal speciation in the river Zenne, a complex and heterogeneous system influenced by the Brussels' sewage disposal and characterised by a strong human impact on a small catchment (i.e. 1260 inhab/km²).

Geochemical codes for equilibrium modelling with Visual MINTEQ will be used to predict metal speciation in the Zenne, as well as the impact of incidental discharges in the Brussels' region. The model will be applied totime seriesmeasurements gatheredfrom September 2009 to July 2011 using longitudinal profiles between Lembeek and Heffen (Belgium).

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Connectivity of *Scylla serrata* in Kenya and the Indian Ocean

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Most of the studies conducted on the genetic population structure and gene flow of marine organisms have been focused on the genetic analysis of mitochondrial markers. Fratini *et al.* (2002, 2010) studied the genetic differentiation of *Scylla serrata* in the east African coast and found that the populations were genetically not homogenous. To better understand the population structure and the gene flow of *Scylla serrata* in and around the Indian Ocean, we propose to take more samples in Eastern Africa (Kenya) and to add more sequences from the entire Indian Ocean. The study area is located in the Southern part of the Kenyan coast. Samples were taken in Lamu Archipelago, Mida Creek, Kilifi, Mombasa, Gazi Bay and Shimoni. More samples were also received from South Africa, Madagascar, Zanzibar, Malaysia, Indonesia and China. On one hand, the results of this study will be compared with the results of Fratini *et al.* (2002 and 2010) in order to determine boundaries of populations and verify whether those genetic patterns are stable over time at a local scale (e.g. in Kenya). In the first analysis, no significant differences have been reported between the three periods of sampling (2000, 2009, 2011). Which could mean that the patterns are stable over time. However tests of deviation from neutral molecular evolution seemed to indicate a departure from the neutral hypothesis for five of the six stations, which could involve population expansion or selection. Haplotype diversity shows high values, unlike the nucleotide diversity, which could be a sign of a recent population expansion. Finally, the populations seem to be homogenous along the Kenyan coast and no structure has been detected. On the other hand, more samples from the wider Indian Ocean will be added into the database to better document the global geographic distribution (larger scale) of *Scylla serrata* around the Indian Ocean.

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The feeding ecology of four semi-pelagic fish species in the North Sea: a case of Belgian water

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On a global scale there is an evolution taking place from marine systems dominated by demersal fish species (and fisheries) towards systems with more (semi-) pelagic fish. Unlike the benthic ecosystems (benthos – demersal fish), the pelagic ecosystem in the Belgian part of the North Sea is little studied. In the pelagic foodweb zooplanktonic organisms play a key role as primary food source for higher trophic levels such as fish and seabirds. The aim of this study is to assess and compare the link of pelagic fish and their planktonic food sources of the Belgian part of the North Sea.

The stomach content results were combined with results from the piscatorial and planktonic research in order to reflect on the energy fluxes (production/consumption) present in marine foodweb. A total of 140 stomachs of Herring (*Clupea harengus*), Sprat (*Sprattus sprattus*), Mackerel (*Scomber scombrus*) and Horse mackerel (*Trachurus trachurus*) were analysed under microscope at ILVO laboratory. The selection of prey types was estimated using a selectivity index (Chesson, 1983) and stomach contents were compared between fish in a time period using non-metric multi-dimensional scaling (non-metric MDS). Differences between tows were tested using randomization tests based on permutations of the similarity matrix.

In order to assess the evolution within this pelagic ecosystem, indicators were and still are developed based on this zooplankton. Because of this, monitoring spatial and temporal variations within planktonic ecosystem is crucial. Due to present climate changes the distribution of certain marine organisms has moved north with more than 10 degrees during the previous 30 years.

This study compares current distribution data with data from the past, to see whether changes in distribution have occurred. Have we lost certain species? What about new/invasive species? What are the peak densities and at what time of the year are they found?

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Enhancing diatom lipid production through metabolic engineering, first phases

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The biological productivity of marine heterokonts, and specifically diatoms, is one of the major contributors to the marine foodweb. In growth limiting conditions diatoms store energy and carbon in the form of lipids. Despite the fact that part of these lipids are nutritionally beneficial omega-3 polyunsaturated fatty acids, they are not yet directly employed for human or animal consumption. One of the main reasons is the limited diatom lipid productivity which limits their economic potential. In this project we will attempt to remedy this problem through genetic engineering to increase lipid productivity. We are aiming to identify the key regulator genes that drive lipid synthesis. Our methodology is based on functional genomics and focuses on the model diatom *Phaeodactylum tricornutum*, as it genome has been sequenced and stable transformation is possible. We are using RNA-seq to sequence the transcriptome of *P. tricornutum* during stress conditions that induce lipid synthesis and we will compare these transcriptome profiles with an exponentially growing control. In this way we map the metabolic reprogramming that cells undergo during the switch from growth towards carbon storage and lipid production in particular. Since we are mainly interested in the regulators of this program and, to a lesser degree, in the enzymes actually effectuating this change we are performing our analysis during the first 24 hours of growth under limiting conditions. In the second phase of the project we will attempt to activate this program during conditions that favor exponential growth. It is our goal to get the diatoms to continue growing while also investing into lipid production. The first results show that *P. tricornutum* lipid productivity can be enhanced above baseline conditions through overexpression of genes as proven by ectopic overexpression of an endogenous malic enzyme isoform. Preliminary transcriptome analysis using cDNA-AFLP shows that 2-5% of genes respond to growth adverse growth conditions. Furthermore our detailed metabolic analysis shows that there are quantitative changes detectable in chrysolaminaran and lipid storage products. These changes appear to be coupled to cell cycle progression. While commercially relevant production has not yet been achieved, it is clear that important insights into physiological stresses will be gained through this project.

A survey of metal contamination in small urban rivers around the city of Dar es Salaam (Tanzania) – prevailing levels in sediment, water and implications for bioaccumulation in invertebrates and fishes

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Rivers passing across major cities are subject to a significant amount of metal contamination from industrial, domestic and sometimes mining sources. Most of the contamination is a result from the lack of or poor treatment of wastes (Kihampa *et al.*,2010). Like other developing countries cities, Dar es Salaam, the big city of Tanzania, faces a problem of river contamination passing across improper or untreated wastes. Most studies have been looking on the concentration of metals in sediments and water, leaving behind fishes and invertebrates that are important for health aspects. Therefore the objective of this study is the assessment of metal contamination in sediments, water and invertebrates and fish in four small urban rivers (Kizinga, Msimbazi, Tegeta and Nguva) in Tanzania and comparing them with those from four sites of Molse Nete in Belgium. The aim is to determine their level in each compartment and potential threat to human health.

Samples were collected from three sampling sites along each river during summer holiday in Tanzania and four sampling points in Belgium in the winter season of October 2011. In Tanzania three fish species (*Tilapia mozambicus*, Cyprinidae and Cichilidae) were caught with mosquito mesh size net and dorsal tissue and tail cut. Five identified species of invertebrates (*Lumbricus*, *Thiara, Neritina,* Neritidae and Gomphidae) were caught. Both fish and invertebrates were stored in polypropylene tubes. Three replicates of water and 1mm upper layer of sediment using petri dish were collected from each sampling point of rivers involved and stored in polypropylene tubes and polyethylene bags respectively. Water was filtered before removing solid particles. In Belgium three fish species for this study were captured with a stupefying electric fishing device, collected and dorsal tissues, liver and tail fins put in polypropylene tubes. The invertebrates were also captured, identified and put in polypropylene tubes and epjes. Sediments were collected with grab sampler. Water was also taken and put in polypropylene tubes for further laboratory analysis.
So far fishes and invertebrates were weighed, samples oven dried at 60°C and will be digested with nitric acid (HNO_3, 69%). Further metal analysis is ongoing in the laboratory. High Resolution Inductively Coupled Plasma Mass Spectrometer (HR-ICP-MS) will be used.
Samples will be compared using Non-multidimensional scaling (NMDS) and PCA. AOSIM will be used to test for significance difference. T-test will be used to test means of correlated metals. The test can be changed upon necessity.

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Estimating primary production form continuous oxygen data in the Schelde Estuary

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Industrial and agricultural pollution in the 20th century transformed the upper part of the Schelde Estuary into a hostile environment. Fortunately, due to waste water treatment, this trend has been reversed and several species now recolonize their former habitat. In order to understand and protect the oligohaline and freshwater reaches, long term monitoring campaigns started from the mid 1990's. Besides these monthly sampling campaigns, Universiteit Antwerpen installed a continuous data logger for oxygen, temperature, pH, turbidity, salinity, conductivity and recently NO_3 and NH_4. These continuous data could illuminate short term fluctuations in water quality such as peak events that are missed with monthly sampling techniques. Furthermore, based on continuous oxygen data, estimates of gross primary production (GPP) can be made. In estuarine systems, oxygen data typically exhibit a complex wave function. We can split this wave function into basic sine functions of different frequencies by performing a Fast Fourier Transform. The sine function with a 24h periodicity will approximate GPP since GPP is the main process with a diurnal periodicity. Compared to the labour intensive ^{14}C-incorporation method, our approach avoids "bottle effects" because oxygen levels reflect the real GPP.

Wetland suitability and connectivity for migratory birds along the Ionian flyway in Greece

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In the annual cycle of long-distance migrant birds, en route periods provide numerous challenges, risks and selective pressures. Intact migratory routes with adequate stopover opportunities are critical for survival, especially for birds that depend on restricted wetland areas during migration. Conserving migratory pathways for wetland dependent birds poses a unique set of challenges, because many reserves scattered across space are required for the conservation of any one species. The Balkans is very important for Palaearctic migratory wetland birds. Especially Greece, with its extension deep into the Mediterranean, forms a bridgehead from and towards Africa.

Our research intends to study the connectivity and the suitability of stopover sites for migratory wetland birds in western Greece. We evaluated site appropriateness for seven migratory bird species with different habitat needs through an extensive field campaign. High resolution satellite images (Google Earth Pro) were used to accurately classify all wetland sites by a typical vegetation classification and by assigning bird habitats based on our expert-knowledge. Our field campaign was performed during the peak migration of our focal species in April-May and included direct validation of site suitability by bird sightings and assessment of all possible, mostly human, disturbances for migratory birds. These disturbances might lead to possible reduction in suitable and available habitat for migratory birds.

Wetland connectivity will be assessed by applying a Flight Leg Allocation Problem model (FLAP), a distance-constrained shortest path problem (Downs Horner, 2008). It finds the optimal path between an origin and a destination habitat in the fewest number of stops and in the shortest distance. Since routes and sites during migration are relatively restricted, it might appear that some geographic locations are more critical than others for a particular species. This differential importance of sites and biotopes along migratory pathways allows us to suggest priority sites for conservation in Greece and possibly the wider Balkans for the protection of migratory birds. This is important in view of the political complexity and jurisdictional boundaries migratory birds cross while flying EU and non-EU stretches along their route. We also focus on the conflict between optimal migration route and the legal status and actual state of stopover wetlands.

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Oceans and Human Health

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The oceans and coastal seas provide mankind with many benefits including food for around a third of the global population, the air that we breathe and our climate system which enables habitation of much of the planet. However, the converse is that generation of natural events, such as hurricanes, severe storms and tsunamis, can have devastating impacts on coastal populations, while pollution of the seas by pathogens and toxic waste can cause illness and death. Estimates from UNEP are that on average 250 million cases of gastroenteritis occur worldwide every year from bathing in contaminated water, and 50,000-100,000 people die from infectious hepatitis as one example. Harmful effects from biogenic toxins produced by algal blooms (HABs) are also a health hazard in seafood and from direct contact with water. The overall global burden of human disease caused by sewage pollution of coastal waters has been estimated at 4 million lost person-years annually. An holistic systems approach that considers whole ecosystems and their sustainability, such as Integrated Coastal Zone Management, is necessary to address the highly interconnected scientific challenges of increased human population pressure, pollution and over-exploitation of food (and other) resources as drivers of adverse ecological, social and economic impacts, and the urgent and critical requirement for effective public health solutions to be developed through the formulation of politically and environmentally meaningful policies.

The research community required to address OHH in Europe is currently very fragmented and recognition by policy makers of some of the problems, outlined in the list of challenges above, is probably limited. Nevertheless, relevant key policy issues for governments worldwide include the reduction of the burden of disease (including the early detection of emerging pathogens) and improving the quality of the global environment. Failure to effectively address these issues will impact adversely on efforts to alleviate poverty, sustain the availability of environmental goods and services, and improve health and social and economic stability; and thus will impinge on many policy decisions, both nationally and internationally.

Knowledge Management (KM) will be a key element of any ensuing research. KM will facilitate the integration of biological, medical, epidemiological, social and economic disciplines, as well as the emergence of synergies between seemingly unconnected areas of science and socio-economic issues, and will help to leverage knowledge exchange (KE) across the EU. An integrated interdisciplinary approach is an effective way to bring together the necessary groups of scientists, social scientists, economists, industry and other stakeholders with the policy formulators in order to address the complexities of interfacial problems in the area of environment and human health.

The Marine Board-ESF Working Group on 'Oceans and Human Health' has been charged with developing a Position Paper on this topic with a view to identifying the scientific, social and economic challenges and making recommendations to the EU on policy-relevant research and development activities in this arena. The background to health-related issues linked to the coastal environment is briefly outlined below and the arguments for the urgent need for future investigations are developed.

Mangrove species turnover in Mida Creek over a period of 12 years

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Mida Creek is located about 100km north of Mombasa, Kenya and has a narrow opening towards the ocean. Mangrove forests are of ecological and economic importance to the local communities in Mida Creek and are therefore not pristine. There has been increasing diversified use of mangrove products such as wood for house construction, boat building, fuelwood, and charcoal. Minor uses of mangrove products include pharmaceutical and medicinal applications, furniture making and tanning material. Studies of the mangrove vegetation using sequential aerial photography have shown that autogenous changes can occur in mangrove ecosystems (Dahdouh-Guebas *et al.*, 2000). Follow-up assessment is thus important to determine the floristic composition following such human disturbance of varying magnitude and changing environmental conditions.

Belt transects of 10 meters width were established both perpendicular and parallel to the creek shores and divided into zones corresponding to vegetation types. In each zone, a square plot of 10m by 10m was established. In high-density areas, 5m by 5m sub-plots were set up while in low-density areas, 20 by 20m^2 plots were established. GPS coordinates were then taken in each plot. Species name, stem diameter, height, form classes based on straightness of poles, and regeneration classes of saplings and seedlings were recorded as vegetation characteristics in 150 plots. Cut tree stumps were also counted and percentage cover of the canopy estimated per plot.

The bulk data serve to determine mangrove tree density, abundance, importance values and floristic composition for adults, juveniles and young trees within and between plots. This ongoing study aims at evaluating the implemented management and utilization of the resources of the area and suggesting management practices, based on the mangrove changes over 12 years since a similar study was done (Kairo *et al.*, 2002). This will be put against the background of the role of Mida Creek as a wetland of importance both to local communities and to internationally recognized nature values.

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Multifunctionality in mangrove ecosystems: the social network approach

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The relationship between biodiversity and ecosystem functioning (hereafter EF) has emerged as one of the central topics in current ecological research owing to the alarming rates of species loss. While the major proportion (72.96%) of EF studies has been carried out on terrestrial ecosystems, aquatic ecosystems including estuarine ecosystems like mangroves have received scant attention. The aim of this current research is to understand the EF of mangroves which are known for providing a host of ecosystem services. Mangroves merit urgent research attention since more than 35% of the world's mangroves have been lost in the past two decades alone. Using a novel approach of utilizing tools developed in Social Sciences (Social Network Analysis-SNA) we attempt to answer the following fundamental questions in mangrove ecology: i) Which functions are important in a mangrove? ii) Which species are more functional than others? iii) Are there keystone species in mangroves? We begin by defining which functional elements exist in a generic mangrove based on a meta-analysis of published literature. Then we use SNA to build a theoretical network of mangrove species and their functions. This research is perhaps the first systematic attempt to analyze the functionality of mangroves from a multi-functional perspective using tools outside the domain of ecological sciences. The outcomes of this study are also expected to serve as a guideline to policy makers and restoration ecologists working on mangroves worldwide.

RV BELGICA II: a new oceanographic research vessel to replace the existing A962 Belgica

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The present-day Belgian oceanographic research vessel A962 Belgica is a twenty-eight-year-old research platform. Although the Belgica continues to perform scientific activities for ca. 180 days a year, the renewal of the vessel should be anticipated. The lifetime of a research vessel is approximately 30 years (Binot *et al.*, 2007).

In 2009 a feasibility study was ordered by the Belgian Science Policy Office (BELSPO) to assess the best future options for the A962 Belgica, i.e. replacement by a new oceanographic research vessel or modernizing the existing vessel. The main conclusions of this study are:

i. RV Belgica is overall in good working order but obsolescence of certain equipment together with (hidden) corrosion and the lack of space and comfort are troublesome for a modern oceanographic research vessel.
ii. The ship time demand in terms of researcher units (8 hours) expressed by the Belgian scientific community (questionnaire 2008) would lead to a total of 10,000 units compared with the current 4,000/5,000 units. The current vessel operated by one crew can certainly not accommodate for this demand.
iii. The scientific community insists the new ship should be a multipurpose research vessel (for hydrography, geology, biology, oceanography, fisheries, environmental sampling, etc.) with dynamic positioning capabilities, with an autonomy of four weeks, with more space and ideal for large-scale equipment (AUV, ROV, coring, etc.) and with a minimal ice class.
iv. Multipurpose oceanographic research vessels belonging to the regional/ocean class will be lacking in Europe in the near future. Therefore a pan-European approach regarding transnational access, design, pooling of equipment etc. should be fostered (cfr. EC-FP-7 EUROFLEETS project).
v. Regarding the financial, technical, statutory aspects modernizing the existing vessel can be abandoned as a feasible option; acquiring a new oceanographic research vessel is the only option.
vi. A time schedule of 5-7 years should be foreseen and a budget of >50 M€ (VAT excl.) is required.

A new research vessel Belgica II will be completely compatible with the new Flemish research vessel Simon Stevin. As the present day RV Belgica, the new RV Belgica II will perform multiple day (5-20 days) expeditions whereas the RV Simon Stevin generally will perform daily expeditions. The new RV Belgica II will be a larger ship (preliminary dimensions as an outcome of the feasibility study: overall length 65m, breadth 17m? draught 4.6m) and will perform scientific tasks in the regional Belgian and nearby European waters whereas the RV Simon Stevin is much smaller (36m by 9m by 3.5m) and will operate in Belgian coastal waters. The difference in working area and in expedition duration shows that both research vessels are indeed compatible. The two research vessels, RV Belgica II and RV Simon Stevin, will accommodate for the growing demand in marine research and knowledge.

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On the hidden half: testing precision of techniques used in estimating below ground biomass in mangrove forests

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Tropical deforestation has been associated with the net emission of 20% of carbon dioxide to the atmosphere (IPCC 2007). Reducing Emissions from Deforestation and forest degradation commonly called REDD+, is a potential market based approach in forestry that can be considered in mitigating climate change through carbon capture and storage (Donato *et al*., 2011). For REDD to work, accurate monitoring of C pools and emissions is required thus the importance of robust C storage estimates for various forested ecosystems. Overlooked in climate change mitigation strategies are mangroves, which are highly efficient carbon sinks for atmospheric CO_2 along tropical coastlines (Donato *et al*., 2011). Critical uncertainties remain, however, before sufficiently accurate and precise estimates of mangrove C storage and land use emissions can be given. Field studies of mangrove biomass and productivity are difficult due to the soil conditions and the site and species-specific dependencies render universal conclusions unreliable (Komiyama *et al*., 2000). In mangrove forestry, most biomass studies have tended to concentrate on aboveground components and there is no standardized methodology to estimate belowground biomass, which was estimated to contribute about half of the vegetative carbon sequestered by these forests. Three common methods are used in mangrove biomass estimation: complete excavation (Ong *et al*., 2004), coring method (Saintilan, 1997) and the trench method (Komiyama *et al*., 2000) . Several biomass studies have been carried out at Gazi Bay in Kenya on mangrove biomass in both replanted and natural stands. Following these studies there has been a great desire to improve on the methodology of determining below ground root biomass in mangroves. To test the accuracy and precision of the three methods used in mangrove forestry, sampling was done at Gazi Bay, Kenya from August 2008 to December 2009 using *Ceriops tagal* (Perr.) C.B. Robinson. The objective is to use root biomass as a proxy to estimating below ground carbon storage. Preliminary results indicate root biomass reduction with increasing distance from the tree base and increasing depth for both the coring and trench methods. We found root biomass consisted of 58%±9.7 of total plant biomass confirming the bottom-heavy structure of mangroves. Parallel to this we intend to further apply allometric scaling techniques in estimating tree weight from measureable tree dimensions based on existing models.

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Can the Kiunga MPA protect the Lamu fishery?

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Lamu Archipelago is located at the northernmost stretch of the Kenyan coastline and it contains the Kiunga Marine Protected Area (MPA), which is situated in the North. Lamu Archipelago is one of most productive fishing grounds along the Kenyan coast. Artisanal fishing is the main economic activity, contributing 70% of the household income. The study seeks to examine the effectiveness of the Kiunga MPA in fisheries resource management. The analysed dataset spans four years (2004, 2005, 2006 and 2008) and data were recorded in March and April. Benthic habitat and fish fauna data was collected at 29 sites using underwater visual census (UVC) and line intercept transect (LIT), respectively, following the reef monitoring protocols of Hill and Wilkinson (2004). Since univariate measures are not always a good measure to detect changes in coral reef fish communities (Khalaf and Kochzius, 2002), also multivariate techniques were utilised for data analysis. The study results show that the MPA has higher fish abundance and that the inner reef have a higher hard coral cover and fish fauna abundance. Sites in the South have higher coral cover but lower fish abundance. Acanthurus leucosternon (Bennett, 1833) and Plectorhinchus gaterinus (Forsskal, 1775) are the two dominant fish species. The fish fauna is dominated by Mullidae and Scaridae and the dominant trophic guilds are herbivores and detritivores. In comparison to a previous study (Obura and Church, 2004), the dominant trophic guilds have changed. Such a change in the abundance of trophic guilds was also observed in a Red Sea coral reef impacted by pollution (Khalaf and Kochzius, 2002). Reef categories, fishing gear, fishing grounds access, and location are influencing factors on the local scale. The MPA is partly effective in mitigating fisheries interactions. Declining trophic levels underscores the influence of harvest regimes outside the protected area.

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Comparison of sedimentation in CRT (Controlled Reduced Tide) and RTE (Regulated Tidal Exchange) restored sites along the Schelde Estuary

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In estuaries formerly embanked land is increasingly restored into tidal marshes and mudflats in order to re-establish estuarine habitats and with that valuable ecosystem services. One of these ecosystem services is water buffering capacity during storm tides, which is negatively correlated with high sedimentation rates. Along the Schelde Estuary (Belgium/Netherlands), tidal marshes and mudflats are restored using different techniques, among them controlled reduced tide (CRT) and regulated tidal exchange (RTE). In the CRT-area (8ha) high inlet culverts and low outlet valves allow a reduced tidal regime of 3m to enter the former agricultural polder. This freshwater site, Lippenbroek, is being monitored from the start in March 2006. In the other project, Burchtse Weel, water enters through low inlet culverts of a newly constructed RTE-area (14 ha). Since the start in January 2011 sedimentation is measured at this brackish site. For both sites the spring tide neap tide cycle is maintained. In natural tidal marshes spatial and temporal variation in sedimentation result in a number of typical patterns for long-term changes in marsh elevation. Changes in elevation are crucial for the colonization and evolution of tidal marsh ecosystems. It may be expected that in marsh systems with a CRT-regime or a RTE-regime sediment deposition mechanisms and consequent changes in elevation will be different from a natural tidal marsh. The low CRT sites are initially characterized by a strong increase in surface elevation (rates between 0.01 to 0.13m per year) and progressively decrease towards approximately 0.085m by the fourth year. Five years after implementation of the tidal regime in the CRT area a characteristic estuarine habitat with marshes, mudflats and creeks formed. However, after implementation of the tidal regime in the RTE area extreme high sedimentation rates (approximately 32cm.month^{-1} at the lowest elevated sites and approximately 6cm.month^{-1} at the higher sites) were observed within the first months. Almost anaerobic, liquid mud covers the whole RTE area; therefore intertidal marsh development and vegetation colonization is expected to occur very slowly.

Growth and structural changes of viviparous mangrove propagules: the effect of environment on dispersal and establishment

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Most true mangrove species are viviparous, meaning that their seeds germinate while still attached to the mother tree. Viviparous reproduction of plants has been linked to wet habitats, such as mangroves, however, it is not yet fully understood what the precise adaptive advantages and disadvantages of vivipary are.

We hypothesize that: (1) the advantage of vivipary is a delayed dormancy period during the (most dangerous) period for the plant between abscission and establishment, as a seedling that is less sensitive than a seed, (2) this delayed dormancy is broken by environmental cues that indicate favourable conditions to trigger root growth and establishment, (3) during establishment, longitudinal growth of the propagule, root growth and leaf development are lower in high than in low salinity conditions and higher when relative air humidity is increased.

This study was conducted in Gazi Bay, Kenya, where two viviparous mangrove species were studied: *Ceriops tagal* and *Rhizophora mucronata*. Mature propagules of both species were collected and placed horizontally on three different substrates, simulating different environmental conditions during the period between abscission and establishment (experiment A). Every six days, small sets of propagules were taken of the substrates and placed vertically in one of three hydroponic set-ups with different salinity and air humidity conditions, simulating different environmental conditions during establishment (experiment B). For both species, no length growth was observed during experiment A, and root growth was not initiated before the 13th day for which the propagules were left on one of the substrates, indicating a period of delayed dormancy and therefore supporting hypothesis 1. During experiment A, propagules that were placed on the drier substrates, dry sand and moist mud, dehydrated more than propagules placed in sea water. *R. mucronata* propagules that were more dehydrated during experiment A, started to form roots earlier than less dehydrated propagules. Therefore we hypothesize that dehydration is the environmental cue that triggers establishment of *R. mucronata* propagules. In contrast, *C. tagal* propagules that had experienced least dehydration during experiment A grew longer roots during experiment B. We hypothesize that humidity stimulates root growth of *C. tagal* propagules. These results support hypothesis 2 as drier conditions are favourable to establish for *R. mucronata* propagules that come from wetter areas and do thus have enough water stored. For *C. tagal* propagules, wetter conditions indicate favourable conditions for establishment as they come from drier areas and thus need some water to be able to establish. As was hypothesized (hypothesis 3), more length and/or root growth was observed for propagules experiencing low salinity and increased air humidity. Leaf growth was only observed for *C. tagal* propagules, of which most were treated with 50 % sea water.

Genetic population structure of the blue starfish *Linckia laevigata* in the Western Indian Ocean

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The blue starfish *Linckia laevigata* is common on shallow water coral reefs of the Indo-West Pacific. Since *L. laevigata* is sedentary, long distance dispersal is only possible by their planktonic larval stage. Previous studies on population genetics of *L. laevigata* have indicated a high gene flow in the Great Barrier Reef and Philippines (Williams and Benzie, 1993; Juinio-Menez *et al.*, 2003). However, other studies report genetic breaks in populations of *L. laevigata* across the Indo-Malay Archipelago and between the Indian and Pacific Oceans (Williams and Benzie, 1998; Kochzius *et al.*, 2009). Only limited information on the genetic connectivity of this species is available for the Indian Ocean, showing genetic structuring between samples collected in South Africa and Thailand (Williams and Benzie, 1998). In the present study, partial sequences of the mitochondrial cytochrome oxidase I gene (COI) will be used as genetic marker. So far, 136 samples were collected from five sites in Kenya (Watamu, Kisite, Tenewi, Mombasa, and Diani) and two sites in Madagascar (Andilana and Sarodrano). It is planned to collect additional samples in Tanzania. The proposed study aims to investigate the genetic population structure and connectivity of *L. laevigata* in the Western Indian Ocean and comparing it to previous studies in the Indo-Malay Archipelago.

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Storms: a challenge of knowledge

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Dealing with storms is always a fascinating matter. They are uncontrollable and destructive.

It is not always possible to get real data measurements during a storm due to large magnitudes involved. To investigate the sea-floor is always difficult, to investigate it during a storm is almost impossible.

Initially, the main purpose of this research was better understanding the sand dynamics in high dynamic environment related to the presence of objects on the sea-floor. Four instruments were deployed in September 2008 to measure the sediment height surrounding themselves at regular time intervals. This allows observing the sand height variation in time and space in the vicinity of a generic obstacle in a dynamic environment.

During the recording period, two storms passed the experiment site, in October and in November 2008. This gave the rare opportunity to observe and analyze data directly measured on the sea-floor and during storms. It was a chance to study the influence of storms on the sediments surrounding a cylindrical object, and how this affects the coverage, as also, the visibility of the object.

Interesting was to observe an exposure of the object with the onset of the storm reaching a minimum burial during maximum wave heights and maximum wave energy. A roll event was always observed in correspondence to this minimum burial. Moreover the combined action waves-currents at the seafloor produced scouring around the object.

A deposition phase started immediately after the main storm. Also the processes during this sedimentation phase were observed.

Storms, sediments, objects and sea-floor: what a challenge of knowledge!

Specific temperature requirements for different vegetation formations of mangroves along its North-South distribution towards its upper latitudinal limit in South Africa

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Despite their global restriction to (sub)tropical coasts, little is known about the temperature conditions limiting the distribution of mangrove trees, except for the fact that freezing can be lethal to them. Worldwide, temperature variation among the upper latitudinal limits of mangroves is high and frost events do not occur at most of these limits. Because of global warming and the need for good management practices, it is important to study the drivers of the mangrove distribution at every upper latitudinal limit.

In South Africa, mangrove forests occur along the east coast and reach their southern latitudinal limit along the West-Indian Ocean at 32.6°S. Three species, *Avicennia marina*, *Bruguiera gymnorrhiza* and *Rhizophora mucronata*, are present in these mangrove forests. Along this North-South gradient of the mangrove distribution in South Africa towards its latitudinal range limit, vegetation structure (dominant mangrove species, adult tree height and abundance of each species) changes.

In this study, we investigated whether the above vegetation changes are due to specific temperature requirements. Therefore, we put dataloggers of relative humidity, air- and soil temperature in four mangrove forests that are marking a shift in vegetation structure. This approach is new because so far, long-term records of daily temperature and relative humidity in mangrove forests were not available. Today, we present an overview of the vegetation structure and the weather circumstances in these four mangrove forests and we define the specific temperature requirements for the different vegetation structures.

Investigating the influences of rapid climate change on the Moroccan Atlantic slope during Marine Isotope Stage 3

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The main geodynamic setting of the Moroccan margin (southern Gulf of Cadiz) is caused by the oblique convergence of the African and European plate resulting in a compressive regime. An accretionary wedge was formed by the westward motion of the Gibraltar Arc front during the Middle Miocene (Foubert *et al.*, 2008). As a consequence of increased subsidence, large olistostrome complexes, forming allochtonous nappes, were emplaced during the Tortonian. Above the olistostrome unit a 0.2 to 2km thick Neogene sedimentary cover was established. This cover is pierced by mud volcanoes, salt diapirs and fluid escape features showing evidence of strike-slip and compressional deformation (Medialdea *et al.*, 2004). This also has lead to the formation of slope-traversing ridges such as the Renard ridge with the steep Pen Duick Escarpment in the El Arraiche mud volcano province. On top of this escarpment, dormant cold-water coral mounds were discovered (Van Rooij *et al.*, 2011)
The hydrodynamic context of the Gulf of Cadiz is complex. There is an interaction between the Mediterranean Outflow Water (through meddies), the Antarctic Intermediate Water and the North Atlantic Central Water (Richardson *et al.*, 2000). Even a multitude of smaller water masses and currents are affecting the area. Sea surface temperature, turbidity and the hydrodynamic setting changed in the northern part of the Gulf of Cadiz during the last 50ka. These changes are attributed to Heinrich events (HE) and Dansgaard/Oeschger (DO) oscillations (Cacho *et al.*, 2001). Palaeoceanographic studies, however, in the southern part of the Gulf of Cadiz are rare, creating a knowledge gap for the spatial and temporal evolution of oceanographic drivers for cold-water coral ecosystems.
Marine sediment core MD08-3227 (33m) taken off-shore Morocco in the Gulf of Cadiz into a Plio-Pleistocene sediment drift will be analysed on sedimentary composition and grain size distribution for a paleoceanographic study. Previous XRF Ca scanning results indicated a long time frame up to 300ka. It is assumed that the terrigenous input increase during dry periods, while it decreases during humid periods. This variation should be represented in the grain size distribution and would as a consequence be a good indicator for the palaeoclimatic changes. Sampling of the core will be performed at regular intervals covering the Marine Isotope Stage 3 (last full glacial period) and will shed more light on the impact of HE and DO events on bottom current circulation. The collected sediment samples will be sieved in wet conditions with distilled water separating the different fractions. Sortable silt fraction will be analysed with the Sedigraph providing a high resolution grain size distribution (mean grain size, sorting, kurtosis and skewness).

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Genetic population structure and connectivity of the mud creeper *Terebralia palustris* (Linnaeus, 1767) in Kenya and Madagascar

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The 'South Equatorial Current' (SEC) in the Indian Ocean, which flows westward along 10°S in the eastern basin and shift to 15°S west of 80°E (Grodsky and James, 2001), could facilitate the dispersal of propagules, which is important for recolonisation, especially after disturbance events. *Terebralia palustris* (Potamididae: Gastropoda), also known as the mud creeper, is the largest prosobranch in mangrove habitats (Pape, 2007). It has a high importance in the nutrient cycling process in mangrove forests by its significant processing amount of leaf litter (Slim *et al.*, 1997; Fratini *et al.*, 2004). Despite their wide distribution, abundance, and ecological importance in mangrove systems, there have been no studies on connectivity and genetic population structure of this species. However, it is known that the eggs deposited by the females on the roots of mangroves hatch into free-swimming planktonic larvae, which could have a high dispersal potential. The genetic population structure will be analysed by sequencing the mitochondrial cytochrome c oxidase subunit I gene (COI), constructing a haplotype network, and conducting an Analysis of Molecular Variances (AMOVA). Samples have already been collected from several sites in Madagascar and Kenya. Additional samples are planned to be collected in Tanzania. This study aims to evaluate the connectivity of different populations of the mud creeper in Madagascar, Kenya, and Tanzania.

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The secret life of Atlantic cod (*Gadus morhua*) at a wind farm in the Belgian part of the North Sea: where ecology meets economy

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A substantial expansion of offshore wind farms in the North Sea (BPNS) has been planned, inducing a growing interest in the possible effects of these artificial habitats on the marine environment. Demersal fishes are likely to be affected by these changes in the environment. The offshore wind turbines may provide a suitable habitat for hard substrate dwelling fish since hard substrates, e.g. shipwrecks and windmill artificial reefs (further referred to as WAR), have been reported to attract and concentrate fishes and/or to enhance local fish stocks.
Since 2009 the trophic ecology and community structure of Atlantic cod has been investigated at the wind turbines on the Thorntonbank. In this study, the state of the art of ecological knowledge of Atlantic cod inhabiting WAR in the BPNS after three years of environmental monitoring is given.

Reubens *et al.* (2010) revealed that high densities of Atlantic cod were present in the vicinity of the WAR in summer and autumn. Research on length-frequency distribution in combination with a migration study based on acoustic telemetry disclosed that Atlantic cod between 2 and 3 years old arrive at the WAR in spring, stay throughout summer and autumn and leave the area in winter time. Furthermore, the (ongoing) migration study (Reubens *et al.*, 2011) revealed high site fidelity and residency near the WAR. Investigation of the feeding ecology revealed the high dependency of hard substrate associated epifaunal prey items in the diet of Atlantic cod caught near WAR.

It can be concluded that the WAR play an important role in part of the life history of Atlantic cod in the BPNS. Every year, large aggregations of Atlantic cod dwell in the WAR and feed there throughout summer and autumn.
Atlantic cod has considerable economical importance; hence several fishing industries lobby to allow small-scale fisheries within this 'de facto' marine reserve. However, as fish aggregation may easily lead to overfishing it is important that thorough management restrictions are implemented and careful monitoring continues in the long term.

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Nitrogen fixation in the Northeast Atlantic Ocean

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The biological carbon pump is one of the main processes to store atmospheric CO_2 in the deep sea. In order to keep this process going, organisms need nitrogen since it is an essential element to all life forms. To biota in oligotrophic open ocean environments, this nitrogen is often a limiting nutrient as large amounts disappear to the deep sea. Especially in the North Atlantic ocean where surface waters cool and sink to the ocean floor, the NO^{3-} concentrations are often below the detection limit of 0.1µM. Together with internal cycling and nutrients from upwellings, the incorporation of new atmospheric N_2 by nitrogen fixation is a source of nitrogen for biota. It is a vital aspect in understanding the mechanisms that control our oceans and thus its impact on climate change. Yet little is known about the importance of this nitrogen fixation to the primary production. The subtropical North Atlantic is an interesting region to study this fixation of new nitrogen because of low nutrient concentrations and the availability of iron, originating from Sahara desert storms. It is thought that this extra iron supports the production of new nitrogen, available to marine organisms, by nitrogen fixation. The objective of my master thesis is to determine the rates of nitrogen fixation and its contribution to the primary production. To obtain the absolute contribution of N_2-fixation, stable ^{15}N an ^{13}C isotope incubations were performed during a nine days cruise south of the Azores archipelago. For the N_2-spiking a new method was used since recent papers reported a significant underestimation of the fixation rates with previous techniques. Instead of injecting N-15 enriched N_2 gas directly in the incubation seawater, low nutrient seawater in which enriched N_2 gas was dissolved was used. The samples taken on the cruise will be further analyzed during the following months.

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Assessing the environmental impact of offshore wind farms in the Belgian part of the North Sea

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By 2020, renewable energy sources should account for 13% of the Belgian electricity consumption. Offshore wind farms are expected to contribute about one-tenth of this demand. In May 2004, the Belgian government designated a zone for the construction and exploitation of installations for the production of energy from water, currents or wind. Every proposed project has to acquire a number of federal permits, including the environmental permit. The environmental permit procedure includes an environmental impact assessment (EIA) by the MUMM. The EIA pertains to both direct environmental impacts (such as on biodiversity, fauna, sediments and hydrodynamics) as well as more indirect environmental impacts (such as oil-spill risks and green house gas emissions), and sociological impacts (such as on seascape or effects on other maritime activities). The EIA is based on an environmental impact study (EIS) submitted by the applicant, on the currently available scientific knowledge and on the results of existing monitoring programmes. Since 2004, three offshore wind farm projects, totalling ~880 MegaWatt installed capacity, have been granted environmental permits, with a fourth project currently in the licensing procedure. Every environmental permit comes with a number (site- and project-specific) conditions aimed at mitigating or minimizing the environmental impact of the activities. When certain unavoidable environmental impacts are foreseen during the EIA, a coordinated long-term monitoring programme is drafted to determine the extent of these impacts.

Nematode community structure and diversity on intertidal beaches at Bandar Abbas (Persian Gulf)

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Marine nematodes are the most abundant metazoans, both in species numbers and density, in a variety of marine sediments. Hitherto, there are however no published studies on marine nematofauna from the Persian Gulf area. In this study, the abundance, genus composition and biodiversity of nematodes of intertidal sandy beaches at four locations at Bandar Abbas on the northern part of the Persian Gulf, are investigated. In each sampling location, we selected three stations along a distance gradient from a local pollution source. The univariate descriptors of nematode abundance and genus diversity were analysed using ANOVA with the factor station nested in the factor location. Community composition was analysed using multivariate statistics.
A total of only 39 genera belonging to 17 families were identified, which is low compared to most previous studies on beach nematofauna. There were significant and consistent differences in abundance as well as genus diversity between locations. Sediment granulometry correlated positively with genus diversity, and the location exposed to the strongest pollution input had the lowest nematode diversity but at the same time a high nematode abundance. Distance from the pollution source only had a significant impact on genus number and on taxonomic distinctness, a diversity index which measures the average phylogenetic distance between any two genera in the community. In the whole study area, five genera (*Daptonema*, *Ptycholaimellus*, *Paramonhystera*, *Terschellingia* and *Theristus*) together comprised 75% of the nematode communities. Several of these dominant genera had their highest relative abundances in the stations closest to anthropogenic disturbance. Hence, even though the overall low diversity of nematodes indicates that the entire area experiences substantial stress, the local sources of disturbance still had measurable impacts on benthic community diversity.

Coringa mangroves in relation to local environmental conditions on the East coast of India

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This study aimed at investigating mangrove species distribution vis-à-vis environmental conditions and was carried out at 12 sampling sites encompassing Coringa (Wildlife Sanctuary), Gaderu/seaward channels and Gautami-Godavari Estuary (~235km^2). At each site (located at 4km intervals), the tree structural measurements included stem density (nos. 0.1ha^{-1}), basal area (m^2 0.1ha^{-1}), relative density (%), relative dominance (%), absolute and relative frequency (%), and Importance Value (IV) (sum of relative density, dominance and frequency, using the PCQ-Method) (Cintron and Schaeffer-Novelli, 1984; Dahdouh-Guebas and Koedam, 2006); along with physico-chemical observations on water salinity, sediment texture (sand/silt/clay), organic matter and elevation. The mangrove species composition was represented by 9 species amongst which *Avicennia marina*, *A. officinalis* and *Excoecaria agallocha* were abundant and distributed throughout the forest. The (mean) stem density (also diversity) is rich in the sites belonging to Gaderu/seaward channels (8 species, 327nos. 0.1ha^{-1}), followed by Coringa (4 species, 260 nos. 0.1ha^{-1}) and the estuary (3 species, 240 nos. 0.1ha^{-1}). In contrast, higher basal area in Coringa (4.1m^2 0.1ha^{-1}) is attributable to the local protection status. Based on the IV, *A. marina* ranked first with its sheer dominance in 8 out of 12 sites followed by *A. officinalis* (2 sites) and *E. agallocha* (2 sites), respectively. The sediments are of silty-clay in nature, where silt levels increased in the direction of Gautami-Godavari Estuary and clay characterized the mangroves proper. The Gaderu/seaward channels with a strong neritic incursion had higher salinity (>20‰) compared to Coringa and/or the estuary. There are four mangrove species associations (Bray-Curtis similarity: 30%) of which Group-1 represents the widespread distribution of *A. marina*, *A. officinalis* and *E. agallocha*, while Group-2 (*Lumnitzera racemosa*, *Ceriops decandra* and *Aegiceras corniculatum*), Group-3 (*Sonneratia apetala*), and Group-4 (*A. alba* and *Rhizophora apiculata*) are seen only at the individual sites. The Principal Component Analysis (PCA) also revealed significant differences in the environmental conditions that are ultimately responsible for the varied mangrove species distribution at Coringa, Gaderu/seaward channels and Gautami-Godavari Estuary.
In view of possible vegetation (mangrove) structural changes with changes in the local environmental conditions (due to sustained human intervention), it is necessary to evaluate their distributional patterns on long-term field-based observations. Therefore the present results would also be able to assist future investigations in terms of better monitoring/management at Coringa.

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Morphological management as a tool to optimize the three main functions of the Scheldt Estuary: safety, accessibility and ecology

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This study will try to improve the insight in the current bathymetry of the Western Scheldt. Morphological management can give possibilities to optimize and harmonize three important estuarine functions: accessibility, safety and ecology. With morphological management we mean the modification of bed morphology by strategic dredging and disposal of sediment, and construction, adaptation or removal of hard structures such as groynes, dike-protection measures and dikes. The aim is to identify those morphological modifications that can have a combined positive effect on flood defence, port accessibility and ecology.

The impact of different kinds of morphological modifications will be studied using a new hydrodynamic Telemac 2D model of the Scheldt Estuary. The unstructured grid of the model allows refining calculations in areas of special interest. The bed morphology is the key input for the hydrodynamic model, while the output consists of a spatial pattern of water levels and current velocities that dynamically changes with the tide. For the analysis of the model output, we will focus on a number of specific hydrodynamic parameters at specific scales. In the case of flood defence the impact of bed morphological features on tidal flood wave and storm surge propagation or attenuation are assessed. For port accessibility, current velocities and patterns and bed shear stresses that are calculated at the sills will be a measure for the self-eroding capacity at these sills. In terms of ecology, the study will focus on water depths and current velocities that are simulated on the undeep subtidal and intertidal flats. These parameters are known to be closely correlated to the survival of benthic communities (Ysebaert *et al.*, 2002). Based on the above parameters maps like the ecotope maps will be made to assess the impact of morphology on benthic communities.

After building a new model of the entire estuary in Telemac 2D, an extensive sensitivity analysis is done. Scenarios like: single channel versus multichannel estuary, augmentation of the shoals, effect of short cut channels and effect of storage areas and their location in the estuary, will be looked after with the model. Water levels, flow velocities, flow patterns and bed shear stress are the main parameters to assess the different scenarios in function of the three main estuary functions: safety, accessibility and ecology.

Finally three case studies at specific locations (Borsele, Hansweert and Bath) are studied in detail. The historical evolution, the current situation and possible future evolutions are regarded with respect to morphological management and the three main estuary functions: safety, accessibility and ecology. Analysis of historical bathymetries and water levels, hydrodynamic modelling of different morphological scenarios and studying the current situation must result in a better insight, for these locations, on how future developments can be optimized and, in general, on the functioning of the entire system. Moreover, recommendations about how to apply morphological management as a tool for optimizing the estuarine functions should be the end result of this study.

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Flatfish fishery: impact & challenges

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Flatfish are by far the most targeted marine organisms by the Belgian fishermen. Sole (*Solea solea*) and plaice (*Pleuronectes platessa*) indeed take first place with regard to landings value and landings weight, respectively. Both demersal fish species are mainly caught using beam trawls with tickler chains. However, this fishing technique has several well known disadvantages including seabed disturbance (caused by the deep penetration of the chains in the bottom), excessive discards (due to lack of species and size selectivity) and high fuel consumption. Improvements have been made to the fishing gear in order to reduce water resistance and to increase selectivity for species and size resulting in less fuel consumption and by-catch reduction, respectively. However, these adjustments were not assigned as sufficient. Alternative passive techniques such as fly shooting, gill nets or long lines are available which are more selective, result in almost no seabed contact and markedly less fuel consumption. However, these latter techniques currently are hardly economically feasible (gill nets and long lines) or too dependent on the weather conditions to be fully effective (fly shooting). Adequate long-term solutions hence are indispensable to ensure a sustainable and profitable future for the flatfish fishery. The most promising alternative meeting both the fisherman's aspirations and the need for ecological progress is pulse fishing. In this fishing technique, the tickler chains are replaced by electrodes towing over the sea floor and inducing electrical pulses, which elicit an upward movement of the fish enabling its catch without spading the bottom. Pulse fishing, using high frequency and voltage pulses, is currently evaluated for catching sole. Hitherto, several plus points are discernible in comparison to the classical trawl fishery: marked decrease in seabed disturbance, reduction of bycatch of undersized sole and plaice and invertebrate benthos and halved fuel consumption (van Stralen, 2005). Unfortunately, also negative effects such as dislocated spinal cords, hemorrhages and mortality were observed in certain exposed fish species, especially cod (van Marlen *et al.*, 2007; de Haan *et al.*, 2008;). These adverse effects need to be tackled in order to be able to define pulse fishing as an environmental friendly fishing technique. Further studies hence are needed to define and optimize pulse characteristics for stimulating flatfish that are not harmful for (other) exposed marine organisms.

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Seabirds and fishery discards in the Southern North Sea

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The high amounts of discards produced by the flatfish beam trawl fishery constitute a source of readily accessible food for scavenging seabirds. This use of discards has led to a dependence of seabird populations on them. Changes in the quantity of fishery waste disposal are thus bound to cause disruptions in feeding habits and reproductive success of these birds. Such changes are envisaged in the reform of the Common Fisheries Policy in 2013 (e.g. a total ban on discards and/or an increased gear selectivity).

The present study aims at investigating the use that seabirds make of fishery discards in the Southern North Sea, by single and multi-item discard experiments. Vessel-following seabirds in this area are mainly represented by the herring gull (*Larus argentatus*), lesser black backed gull (*Larus fuscus*), great black backed gull (*Larus marinus*), kittiwake (*Rissa tridactyla*) and common gull (*Larus canus*). Consumption of different sizes, shapes and species of discarded fish (mainly whiting, sole and plaice) was assessed, taking into account the different species and age classes of consumers. Differences in the reliance on kleptoparasitism (i.e. food robbery), as well as seasonal or spatial variations in this behaviour were also sought for.

Data from five monthly single-item discard experiments (April-August 2011) where collected onboard RV Zeeleeuw at four different distances off the harbour of Zeebrugge, where a colony of lesser black backed and herring gull is located. These data present age-related differences in competitive ability and reliance on kleptoparasitism, as well as possible time-related variations in kleptoparasitism performed by adults, probably related to the breeding season. The expected time-related changes in the use of discards by different age classes, as well as spatial variation in foraging by different species are also reflected by the obtained data.

Two further campaigns are planned in February and April 2012, where multi-item experiments will be coupled to the presented results. These will allow suggestions on the potential effects of altered discard patterns on seabird populations, and provide the basis for management advice on these side effects.

Assessing the impact of fisheries on demersal resources using ecosystem-based indicators.

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Fishing has been pointed as one of the oldest and main anthropogenic pressures, having an impact on marine ecosystems. Fishing generates by-catch, discards and high grading, the latter being a routine practice in European waters. Existing management systems have been proven to be ineffective to tackle most of the underlying issues. There is a high degree of public awareness about the risks and consequences of overfishing and the need to manage technological innovations and economic incentives wisely in often sensitive ecosystems.

Fisheries management, mainly focused on single species, is shifting to an ecosystem approach to management (EAM)with the objective to sustain both healthy ecosystems and the fisheries they support. Sustainable fisheries are faced with socio-economic difficulties such as excess capital, fast technological progress, labour force redundancy and conflicts between groups of fishermen. In multi-stakeholder settings, different perceptions about spatiotemporal patterns in fish stocks and related activities are important but problematic as they elicit controversies and unbalanced disputes.

Our study will focus on the demersal (living on or near the sea-bottom) fisheries in twoEuropean marine regions with different ecosystem characteristics, the North Sea and the North-eastern Mediterranean. A generic set of SMART (Specific Measurable Achievable Relevant Time-bound) indicators relevant to the EAM will be selected and quantified in the two study areas to assess the pressure exerted on fishery resources, their state, the socio-economics of the fisheries, as well as the governance of the respective fishery systems. Hence, the effectiveness of existing management regimeswill be evaluated and possible recommendations will be provided to stimulate action in improving pursuance of sustainability objectives.

The main target is to develop a generic set of relevant and meaningful indicators that may be applicable to different ecosystems as advisory tools contributing to sustainable fisheries management.New knowledge produced through this PhD project will constitute value added output in line with needs arising by high-level policies' (Marine Strategy Framework Directive, Common Fisheries Policy) objectives.

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Large scale experiments on farms of heaving wave energy converters

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The shrinking reserves of fossil fuels in combination with the increasing energy demand have enhanced the interest in sustainable and renewable energy sources, including wave energy. In order to extract a considerable amount of wave power, large numbers of Wave Energy Converters (WECs) will have to be arranged in arrays or farms using a particular geometrical layout. The operational behaviour of a single device may have a positive or negative effect on the power absorption of the neighbouring WECs in the farm (so-called near-field effects). As a result of the interaction between the WECs within a farm, the overall power absorption is affected. Finally, the wave height behind a large farm of WECs is reduced (Troch *et al.*, 2010; Stratigaki *et al.*, 2011) and this reduction may influence neighbouring farms, other users in the sea or even the coastline (so-called far-field effects).

Several numerical methods have been employed to analyse the response of WECs. Boundary Element Methods (BEM) based on potential flow have been used intensively to study the hydrodynamic interaction of multiple oscillating bodies (near-field effects) for small computational domains. To study far-field effects, a much larger computational domain is required. In this case, wave propagation models are generally employed (e.g. MILDwave (Troch, 1998)).

In contrast to the quantity of numerical analysis of WEC arrays and the large body of experimental work concerning individual or pair of WECs (e.g. Babarit *et al.*, 2009), only a very limited number of experimental studies of WEC arrays have been published. In the last decade, a few experimental measurements of the response and power output of small arrays of closely-spaced heaving floats were reported, e.g. in (Stallard *et al.*, 2008), Supergen programme etc.

Experimental studies concerning wake effects of large WEC-farms (near-field and far-field effects) are not available in literature. Within the HYDRALAB IV European programme, access to the Shallow Water Wave Basin of DHI (Denmark) has been granted for the present research. The objective of those innovative experiments is to cover the gap of experimental studies in the literature and to determine near-field and far-field effects from large farms of Wave Energy Converters. In this research project, the wake effects by farms composed of devices of the oscillating type (point absorbers) are investigated for several farm configurations and various wave conditions.

The main objective of this research is to improve the understanding of wake effects and the modification of wave conditions due to energy extraction by WEC farms. Knowledge of both the behaviour of a single WEC affecting its neighbours (near-field effects) and the shadow effects behind a large farm (far-field effects) including the measurement of the dimensions of the wakes, are important for the design of a WEC-farm.
Moreover, it is essential to understand the behaviour of a 'farm' of Wave Energy Converters under several wave conditions and to quantify the effect on power absorption by modifying: (i) the distances between the WECs in a farm, (ii) the number of the WECs in a farm and (iii) the farm geometrical layout.

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Short-term hypoxia does not affect nematode densities and vertical distribution patterns at the Belgian Part of the North Sea

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We investigated the effect of coastal hypoxia on nematode communities from different sediment types at the Belgian Part of the North Sea (BPNS). Different sediment types are characterised by different biogeochemical environments, which is reflected in nematode densities, community composition and vertical distribution in the sediment. As such, we investigated whether the effect of hypoxia depends on the identity of the receiving nematode communities. Samples were collected at St700 (median grain size: 25µm), St115 bis (median grain size 185µm) and St330 (median grain size 330-360µm), covering a wide gradient of biogeochemical environments. The environmental differences were reflected in significantly higher nematode densities at St115bis. PERMANOVA analysis (relative abundances) did not indicate a significant difference in the vertical distribution pattern in the field situation.

In the lab, oxygen concentrations in the water column were manipulated to reach hypoxic conditions in the water columns (1.34±0.09 mg^{-1}) or to maintain oxic condition (7.70±0.09mg^{-1}). Samples were collected after 1 day (short term effect) and 7 days. Hypoxia in the water column resulted in reduced oxygen penetration depth in hypoxic treatments from Day 1 onwards at St330, and at Day 7 at both other stations. However, as oxygen penetration depth was limited to the upper cm at the onset of the experiment, direct oxygen-related hypoxia effects are limited to the upper cm of the sediment.

Nematode densities and vertical distribution were not significantly affected by the experimental conditions at the start of the experiment. Hypoxia did not affect nematode total densities after 1 and 7 days at any of the stations. Similarly, hypoxia did not affect the vertical distribution of the nematodes at any of the stations.

Our results indicate that nematode communities from different sediment types from the BPNS were not negatively affected by short-term hypoxia, in terms of total densities and vertical distribution patterns. This can partly be explained by the buffering capacity of all types of sediment, as reflected in the relatively small differences in oxygen penetration depth in most of the sediments. On the other hand, nematode communities present at the start of the experiment probably were adapted to life in oxygen-stressed environments, as they were sampled after the deposition of the spring phytoplankton bloom. However, more detailed (but ongoing) analyses of the nematode communities (e.g. at species level) and environmental variables are needed to increase our understanding of the response of different nematode communities to short-term hypoxic events.

The effect of increasing surface water oxygen concentrations on metal mobility in sediments from the Schelde Estuary

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Domestic and industrial waste water was untreated in many Belgian streams for decades. A high organic load resulted in low surface water oxygen concentrations while contaminants, including trace metals, were often concentrated in the sediments. Under these hypoxic conditions the formation of insoluble metal sulfides is found to reduce metal mobility and toxicity in sediments (Di Toro *et al*., 1992). However, after the implementation of waste water treatment plants last years, an increase in surface water oxygen concentrations was observed in many rivers, the Schelde and its tributaries included. Under these conditions, sulfides may be oxidized and associated metals can become more available in the sediment or migrate to the surface water. Then the risk exists that historically contaminated sediments will be turned from a trace metal sink into a trace metal source. In an experimental setup the effect of surface water aeration on trace metal mobility was investigated. Natural sediments from the Zenne and Moerbeek with high concentrations of metals and sulfides were exposed to aerated surface water (oxygen = 90%). This resulted in increasing sediment redox potential values and decreasing sulfide concentrations. Trace metals, precipitated with these sulfides, became more mobile. An increase in sediment metal availability, release to the surface water and higher toxicity to *Daphnia magna* were observed after 2 months exposure to the high oxygen surface water.

Long term field data were used to explore the effects found in the experiments on a larger scale. Due to the implementation of a waste water treatment plant near Brussels in 2007, an abrupt increase in oxygen concentrations in the Zenne surface water was observed. However, this did not result in increasing metal concentrations in surface water of the Zenne, as could be expected based on the experimental results. Also in the Schelde Estuary oxygen concentrations raised the last 10 years but differences concerning the effect on trace metal mobility may exist. The gradual decrease in surface water concentrations of most metals between 1960 and 2005 is followed by a recent increase of some metals in the river water. Additionally, surface sediment metal concentrations in freshwater tidal marshes of the Schelde showed a recent increase. Increasing oxygen concentrations in the Schelde resulting in higher metal mobility in the sediments can be one of the possible explanations.

These results may indicate a large scale mobilization of trace metals from Schelde sediments which contain a huge amount of historically accumulated trace metals. Even when the migration towards the surface water may be negligible in terms of toxicity, a substantial increase in metal availability in the superficial sediment layer can be expected. Since this layer is of main importance for benthic invertebrates and consequently for feeding migrating birds, metal toxicity in this biologically important zone may have a large impact on the estuarine ecosystem.

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The former occurrence of sturgeon in the North Sea – The contribution of archaeozoology and ancient DNA

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Sturgeon was once widespread across Europe and occurred in all major European rivers. Today, this fish is extinct in most Western European countries, including the Low Countries and the UK. It was traditionally assumed that this extinct sturgeon species was the European sturgeon (*Acipenser sturio* Linnaeus 1758), since no other sturgeon species were believed to have ever occurred in Western Europe. However, recent archaeozoological and molecular research on modern museum specimens and sturgeon bones from archaeological sites, has indicated that, in the past, also the American Atlantic sturgeon (*Acipenser oxyrinchus* Mitchill 1815) occurred in several large river basins in France (Desse-Berset, 2009, 2011), Germany and Poland (Ludwig *et al.*, 2002, 2009). This project aims at determining which sturgeon species historically occurred in the North Sea, more specifically in Belgium, the Netherlands and the United Kingdom. To this end, we are currently performing a combined morphological and genetic analysis on sturgeon remains from archaeological excavations in Belgium, the UK and the Netherlands, as well as on modern museum specimens.

The morphological research aims at validating the criteria to distinguish *A. sturio* from *A. oxyrinchus* by the surface morphology of their scutes, formerly described by Magnin (1964) and applied by several other authors (Ludwig *et al.*, 2002; Desse-Berset, 2009). Regarding the surface ornamentation of the scutes, the possible effects of the position of the scute on the body or size of the animal on the surface ornamentation of the scutes have never been verified. Therefore, sturgeon specimens in different European and North American museums are examined. Once valid criteria to distinguish the two species based upon isolated scutes are defined, species identification and size reconstruction will be done for archaeological sturgeon scutes.

In a next step, the results of the morphological study on the archaeological material will be validated by means of mitochondrial DNA analysis on a selection of the archaeological specimens using ancient DNA techniques (paleogenetics). As hybridization could have occurred between both species (Tiedemann *et al.*, 2007), nuclear DNA will also be analyzed to evaluate such possible scenario.

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Evolution of mangrove area in a war and land use change affected region of Vietnam (Ca Mau) over a 60 year period

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Ca Mau Cape is located at the southernmost tip of Vietnam between 8˚32' to 8˚49'N and 104˚40' to 104˚55'E. It has the potential to support a substantial area of mangroves (Hong and San, 1993) and is considered as a natural mangrove ecosystem that has a high biodiversity conservation value and scenic beauty (Tri, 2009). In the US-Vietnam war strategy (1961-1971), large tracks of forest in the Southern provinces were defoliated, through herbicides (Agent Orange), in order to reveal military shelters and food supplies (Stellman *et al.*, 2003). Ca Mau was amongst the most affected areas. Heavy defoliation has not only exterminated the vegetation, but also destroyed the heterotrophic elements and changed the whole ecosystem (Hong and San, 1993).

Since 1978, the Vietnam government established management activities such as reforestation programmes and conservation actions (Binh *et al.*, 2005). Despite these efforts degradation still continues. The major causes are the intensive exploitation of firewood, the expansion of rice farming and the subsequent higher benefits of shrimp aquaculture driving land use change and forest management cycles (Binh *et al.*, 2005; Koedam *et al.*, 2006). In order to stop further deforestation of mangrove forests the Government reformed the national law in 1991 to assure a strict protection of forests (Hong, 2000). The result was not entirely satisfying: although the rate of destruction of mangroves decreased, it could not be halted or reversed. This is the reason for issuing two new laws in 1998, namely the reinforcement to protect and develop forest area as soon as possible and the objective to reforest an extra 5 million ha forests (more than mangrove) spread over the country (Binh *et al.*, 2005).

In this study, aerial photographs from 1953 and remotely sensed image data of Landsat (1975, 1979, 1988, and 2000) and SPOT (1995, 2004 and 2011) images were used to determine land use and land cover changes over 58 years, especially the change of mangrove area in relation with human impacts. The result is very useful for management of mangroves to improve their contribution towards natural resources, ecotourism and the local livelihood.

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Viewing through the clouds in satellite images

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Let us imagine that you want to know the temperature of the sea before taking the plane for your next holidays. If you are lucky, you can ask a colleague taking part of a campaign in that region to measure the temperature for you. Otherwise, you have to rely on numerical models, and if you don't trust them, you can use the informations provided by the more than 3000 satellites orbiting around the Earth.

Satellites will provide you with the temperature at the surface of the sea (SST), but usually they cannot view through the clouds, hence leaving gaps in the images.

In order to fill these gaps, we use a method based on the decomposition into principal modes: with a time series of images, we are able to determine the main spatial and temporal modes of variations, called the EOF's (*empirical orthogonal functions*). This method is implemented in the software DINEOF (Beckers and Rixen, 2003; Alvera-Azcárate *et al.*, 2005).

Using this information, it is then possible to reconstruct the SST under the clouds... and discover if it's warm enough to go swimming.

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Modelling available data for turbot (*Psetta maxima*) in the Irish and Celtic Seas: a first step towards sustainable management?

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Turbot (*Psetta maxima* L.) is an economically very important by-catch species in the European flatfish fisheries. Despite its economic importance, no analytical assessments leading to fisheries advice have been carried out so far. The reason for this is twofold: (1) the available information is inadequate for a detailed evaluation of stock trends; (2) the relatively low numbers of turbot in commercial catches, as well as the high commercial value of this species, make it very difficult to collect data on biological variables in sufficient numbers for a meaningful analysis. Consequently, historic turbot management in the North East Atlantic was based only on an evaluation of trends in landings and effort. Assessing the stock status of turbot remains an important and ever more pressing task, as the 2011-Memorandum of Understanding (MoU) between ICES and the EU requires advice on North Sea turbot from 2011 onwards, and it is anticipated that the request for advice on turbot inhabiting the more westerly fishing grounds will soon follow. As survey time series represents another source of abundance information that was not analyzed for western waters turbot before, this study models the available survey data from 1993-2008 for turbot in ICES-divisions VIIa (Irish Sea) and VIIf and VIIg (Celtic Sea) by means of Generalized Additive Models (GAMs). The results point to a slight increase in population numbers of turbot over the study period. However, these results should be interpreted with much care as scarcity of the data as well as intrinsic uncertainties of the model have to be acknowledged. The model predicts a high concentration of turbot individuals in the Bristol Channel, situated south of Wales, which is a well-known nursery ground for sole (*Solea solea* L.). Previously recognized ecological patterns, such as the relationship between length and depth, are confirmed by our results. At present, performing stock assessments for turbot by means of traditional analytical techniques (such as VPA) is being hampered by the lack of extended time series of catch-at-age data. However, it is feasible to generate relevant insights in population dynamics using more flexible statistical approaches such as GAMs. Improvements in stock assessments can certainly be achieved by implementing enhanced statistical analysis and models, but more attention should be given to improving the quality of the data by re-evaluating current survey designs and addressing fundamental ecological questions for which answers are still lacking.

Occurrence of microplastics in mussels (*Mytilus edulis*) and lugworms (*Arenicola marina*) collected along the French-Belgian-Dutch coast

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The occurrence of microplastics (i.e. plastic fragments < 1mm) has recently been receiving increased attention. Moreover, laboratory experiments have shown that various marine organisms can ingest these microscopic fragments. Microplastics smaller than 10µm were even shown to translocate from the gut cavity to the circulatory system of the mussels. However, in all these experiments the exposure concentrations (range 1,000–50,000mg.kg^{-1}) were much higher than any concentration observed in the field (range 50–200mg.kg^{-1}). As such it is difficult to assess the relevance (risks of adverse effects) of these laboratory observations for organisms living in natural marine environments.

The aim of this project was to study the presence, and if present, the concentrations of microplastics in two marine species collected in the field: (1) the blue mussel *Mytilus edulis* and (2) the lugworm *Arenicola marina*. The mussel is a filter feeder and the lugworm ingests sediment. Hence, the use of these organisms allows, for the first time, the assessment of the potential transfer of microplastics from both the water phase and the sediment matrix to marine life.

Biota (mussels and lugworms), seawater and sediment from the intertidal zone were collected at 6 beaches along the French-Belgian-Dutch coastline, during September-October 2011. Microplastics were extracted from the sediment using elutriation followed by a sodium iodide (NaI) extraction, the latter to separate the lighter plastic particles from the heavier particles. Seawater was filtered and a NaI extraction was performed on the settled particles. Organisms were subjected to an acid (HNO_3) digestion procedure. Quantification of the extracted particles showed that – at all sampling locations – all tissue and faeces samples contained microplastics. Tissue concentrations in mussels were around 2 particles.gram^{-1} of tissue. Lugworms contained 3 particles.gram^{-1} of tissue. As expected, these tissue concentrations are low compared to the concentrations present in the environment: water contained about 80 particles.l^{-1} and sediment 40 particles.kg^{-1} sediment. Although the units are clearly different, these data can be used to illustrate the difference between the environmental and tissue concentrations. Sediment also seemed to have a lower concentration of particulates than seawater. This can be explained by the fact that the sampled upper 5cm of the intertidal zone is a very dynamic system with high perturbation levels, making it difficult for the suspended particles to settle.

The use of these organisms allowed, for the first time, the assessment of the transfer of microplastics from both the water as well as the sediment matrix to marine life.

Selective uptake of microplastics by a marine bivalve (*Mytilus edulis)*

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Microplastics, the degradation product of larger plastic debris, are accumulating in marine habitats worldwide. Given their small size (< 1mm) these particles can potentially be ingested by a wide array of marine animals. Data on the ingestion, and subsequent translocation to the tissues, of these ingested microplastics in invertebrates is, however, scarce. In this study, we tested the hypothesis that the translocation of microplastics from the gut to tissues is size-selective and has an adverse effect on the energy allocation in the mussel.

The blue mussel (*Mytilus edulis*) was exposed to three different sizes of microplastics simultaneously (10, 30 and 90µm) for 14 days. 10µm-particles, as well as 30µm-particles, were added at 50 particles.ml^{-1} and 90 µm-particles at 10 particles.ml^{-1}, resulting in a total concentration of 110 particles.ml^{-1}. Analysis of the faeces demonstrated that *M. edulis* filtered and ingested all particle sizes. In the faeces, the 30 and 90µm-particles were detected in the same ratio as they were added to the seawater (i.e. 5/1). However, the 10µm-particles were detected in much smaller quantities than expected based on the observations of the other particle sizes, i.e. 8 times less than the 30µm-particles were observed (eventhough they were initially present at the same concentration). Although this discrepancy was probably partly due to difficulties in detecting the particles in the faeces, analysis of acid-destructed mussels and hemolymph samples demonstrated that 10µm-particles were able to translocate to the circulatory system of the mussel. Using a syringe, 300µl of hemolymph was extracted from the posterior adductor muscle and on average 15.3±3.2 particles (n=15) were found in the hemolymph of the mussels. This translocation accounts for less than 0.3% of all 10µm-particles ingested. The uptake and translocation of microplastics showed no significant effects on cellular energy allocation. Exposed mussels did show a significant increase in energy consumption, indicating a rise in metabolic activity.

Although *M. edulis* was exposed to a very high concentration of microplastics, which was aproximately 1,000 times higher than the concentration encountered in the field, no significant short-term adverse effects of ingestion and translocation were detected. Long-term exposure studies will be performed to provide more conclusive answers on the effects of uptake and translocation of microplastics in *Mytilus edulis*.

Spatial and temporal evolution of the Le Danois Contourite Depositional System, Southern Bay of Biscay

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More understanding about palaeoceanographic processes and their resulting sedimentary products is necessary mainly due to the increasing interest in these deposits for palaeoclimate reconstruction and for the hydrocarbon industry. Because contourite deposits have not been studied as much as, for example, turbidite deposits, more studies are recently being conducted on them. The principal aim of these studies is to reconstruct the sedimentary architecture of contourite deposits, taking in account for their sedimentary evolution and their palaeoceanographic drivers.
Taking these objectives in mind, research will be performed on the Le Danois Contourite Depositional System (CDS), located in the Bay of Biscay, on the Cantabrian continental margin and constrained in the intra-slope basin, between the Asturias shelf and the Le Danois Bank, between 400 and 1500m water depth (Ercilla *et al.*, 2008). A CDS contains depositional (drifts and sediment waves) and erosive (moats) features that are genetically linked and originate due to the working of bottom currents. The Le Danois CDS was first described by Van Rooij *et al.* (2010), indicating it is the only CDS within mid-water depths in the Bay of Biscay. It is thus an ideal recorder of palaeoceanographic change in this area.

The seismic data used for this research, were acquired during RCMG survey ST1117 in the Bay of Biscay on board of R/V Belgica. The high resolution single channel reflection seismic profiling was performed with a SIG sparker source. CTD measurements, using a Seacat SBE-19 Plus deep-water CTD profiler of the MUMM, were acquired as well.

Visualization, study and interpretation of the single channel seismic records will be made with the aid of the 'The Kingdom Suite' software. Seismic sequences, units and/or subunits, each bounded by seismic discontinuities, can be discerned in the data. These discontinuities have been formed by climatic, sea-level and palaeoceanographic changes in the Mediterranean Outflow Water (Van Rooij *et al.*, 2010; Hernandez-Molina *et al.*, 2011). A relative stratigraphy, based upon stacking of sediments can be made, whereas fine-tuning of the chronology can be done by comparing the deposits and stacking sequences with the well-studied CDS in the Gulf in Cadiz (Hernandez-Molina *et al.*, 2006).

The main purpose of this MSc thesis is to investigate the influence of the Mediterranean Outflow Water and its bottom current flow on sedimentation in the region and to reconstruct the palaeoceanographic evolution of the Le Danois Contourite Depositional System.

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Subsampling beam trawl catches: a necessary evil

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An ecosystem approach to fisheries management shifts the focus from single (commercial) species to wider ecosystem functioning. Such an approach requires data from the entire catch, including non-commercial species such as e.g. benthic invertebrates in addition to the targeted fish species. Such data is rarely readily available from the fisheries industry since it is work intensive and entire catches are often too large and difficult to manipulate. Estimating total catch composition will therefore have to rely on subsampling in order to obtain estimates. This study focuses on the subsample size necessary to obtain reliable estimates of species abundance in flatfish beam trawl fisheries in the southern North Sea.

Required size for a representative subsample depends on the area-specific diversity of the catch and its mixture during catch handling, but since subsamples were taken from a randomized catch, the mixture of the catch was not at stake. Catch diversity and the effect of subsample sizes were addressed specifically. A variety of hauls with different total catches were randomly divided into 10kg boxes. Using an index of relative abundance, each species was classified into different categories individually for each haul: rare, common or abundant. This index clearly indicates that only few species were highly abundant in most of the sampled hauls, such as *Asterias rubens* and *Psammechinus miliaris*. A large number of species were categorized as common, such as *Liocarcinus holsatus* and most discarded species were classified as rare (*Callionymus lyra*, *Aphrodita aculeata*, etc.). Furthermore, a permutation approach was used to identify the number of 10kg boxes required to reasonably estimate species abundance within different ranges of accuracy. This number of boxes required then translates into an acceptable subsample size. As expected, the larger subsample size (i.e. the more boxes used), the higher the accuracy of the species abundance estimate. In addition to this, accuracy leveled off at different subsample sizes for the different abundance categories. Estimations for abundant species required a lower subsample size than estimations for rare species. This study quantifies the abundance specific relationships between subsample size and accuracy in detail and allows recommendations for sampling methodology in the case off flatfish beam trawl fishery in the southern North Sea.

Towards an operational sediment transport model for optimizing dredging works in the Belgian Coastal Zone

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The Belgian Coastal Zone (BCZ) is characterised by shallow waters, with an irregular bathymetry and a systems of sand banks. The bottom sediments generally consist of fine to medium sand. The waters are well mixed due to a high hydrodynamic energy. In the coastal zone, high concentrations of suspended particulate matter occur, where values of a few hundred mg/l are common. The sediments consist here of mud and muddy sands. The high turbidity area results in significant siltation of ports (Zeebrugge and Oostende) and of the navigation channels. Every year, about 10 million ton of dry material – mainly fine-grained sediments - is dredged and dumped back into sea on selected disposal sites. The dumped matter is quickly resuspended and transported away from the disposal sites. Depending on the location of the disposal sites, a significant quantity (up to about 10%) of the dumped matter recirculates back towards the dredging places, resulting thus in an increase of dredging quantities.

To study the recirculation of the disposed fine-grained material, numerical models have been used. In Fettweis and Van den Eynde (2003), a semi-Lagrangian two-dimensional sediment transport model was presented that was used to study the mud balance in the BCZ. The same model was used in Van den Eynde (2004) to simulate the dispersion of (radio-active) material and in Van den Eynde and Fettweis (2006) to investigate the influence of the disposal of dredged material on the sediment balance. The models results have been further validated with long term *in situ* measurements (Fettweis *et al.*, 2010).

The selection of an optimal disposal location, with a high disposal efficiency (low recirculation) is of high economic and environmental concern. It can be achieved by reducing recirculating of the dumped matter towards the dredging places, confining the physical, chemical and biological effects to local areas and keeping the distance between the dumping site and dredging places as short as possible. Different simulations were carried out to investigate how the location of the dumping sites and the meteorological conditions affect recirculation of the dumped material. An operational implementation of fine-grained sediment transport model was set up to predict the recirculation of the dumped material from different possible dumpings sites, taking into account the meteorological predictions for the following days. Using these results the most optimal disposal site can be assigned for the given situation.

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Floating with seeds: understanding hydrochorous mangrove propagule dispersal – a field and modeling approach

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This project aims to map focal areas of natural and dieback of recruitment of mangroves in vulnerable and pristine areas along the Kenyan coast, to study dispersal processes as well as drivers of mangrove dispersal and establishment, all in the light of conservation of mangrove resources and ecosystem services. Understanding and modeling mangrove dynamics is important, both from the point of view of fundamental biological insight and for the construction of socio-economy oriented conservation strategies. In the light of sea level rise (SLR) and global climate change the fundamental aspects must however be seen in a new perspective. Knowing the 'normal' dynamics of mangrove systems is a baseline to model and evaluate various scenarios. Normal dynamics can be compared to climate-driven or anthropogenic dynamics. In spite of the many uncertainties and constraints in validation, modeling the actual situation can be a valuable tool to allow forecasting a future environment, feeding the model with expected future values of established drivers, and strengthening the basis for the formulation of restoration and management policies for sustainable use of the mangrove resource. Continuous assessment and monitoring of the marine and coastal environment and the impact of natural and human-induced changes is fundamental, in order to generate data that will inform rational management and the restoration of coastal ecosystems, as called for by the Kenyan environmental policy. In order to achieve the project aims, a "four-step-methodology" is applied: firstly, pristine and impacted areas are mapped and analyzed in a Geographical Information System (GIS) environment, using field data combined with and expanding previous vegetation mapping. Secondly, an existing hydrodynamic dispersal model (Di Nitto, 2010) is validated on the basis of propagule tracking experiments, which constitute a framework to define parameters that so far have only been approached by proxies or assumptions. Thirdly, this model is elaborated by implementing alterations in sedimentation and topography, since these can significantly influence mangrove (hydro)dynamics, and present a fundamental (model) parameter within the context of climate change and SLR. Finally, the role of external and rare stochastic factors in mangrove dispersal is studied by conducting experiments in NIOO-CEME's flume tank, and making simulations for normal and extreme conditions (i.e. for different wave energies and water flow velocities).

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Dredged material disposal: does it substantially affect the ecosystem?

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To counter the degradation of marine ecosystems, a variety of legislative measurements are being developed, mainly under the umbrella of the Marine Strategy Framework Directive (MSFD). The policy behind this is to ensure that human activities are performed in a sustainable way, which means that the impact of all human activities on the marine system has to be scrutinized. Which human activities have a substantial, not sustainable effect on our marine ecosystem? To avoid a subjective debate, the sustainability of those activities has to be scientifically evaluated from an ecological and socio-economic point of view.
In this study, we illustrate a sustainability assessment of one human activity, namely 'dredge disposal' on the Belgian Part of the North Sea (BPNS). Substantial dredging activities take place in the navigation channels and harbours throughout the year (ca. 10 million tonnes dry matter per year). This dredged material is disposed at 5 designated areas, in total 16 km² or 0.44% of the BPNS surface. The disposal of dredged material may have effects on the water surface, in the water column and on the seabed (MEMG, 2003). Several studies show that the fine sediment plumes that originate from dredge disposal have a noticeable effect outside of the disposal areas (Fettweis *et al.*, 2003; 2011). The sediment plumes influence the turbidity of the water column and results in an increase of the suspended sediment concentration near the bed suggesting the formation of fluid mud layers at the site and in its neighbourhood. The size of the seabed surface that is impacted by the disposal depends on the hydrodynamic conditions and the composition of the disposed material (Van Lancker *et al.*, 2011). Chemical contaminants can be released in the water and sediment through disposal of dredged material, leading to changes in the chemical environment. For the BPNS, however, the concentrations of heavy metals, PCBs and pesticides only slightly differed between control and impact sites, with a small increase noted at 2 disposal sites (Van Hoey *et al.*, 2011). Also, the accumulation of pollutants in marine organisms at the disposal sites seems to be minimal. The disposal activity results further in habitat modifications at certain sites and smothering of the benthic life. This is most visible at the frequently used disposal site Br&W S1, where the extent of the *Abra alba* habitat is slightly reduced and the benthic diversity and abundance is lower than expected (Van Hoey *et al.*, 2011). On the other hand, the disposal activity can invoke a slight increase in benthic diversity, as observed at the disposal site Br&W S2, but also in the far field of Br&W S1. The deposition of fine sediments (silt) in a naturally more sandy area (Vlakte van de Raan) seems to favour several 'mud loving' opportunistic species.
The research at the dredge disposal sites indicates some local and neighbouring effects on the ecosystem (Lauwaert *et al.*, 2011). However, from a socio-economical point of view, it is clear that the dredging and disposal activity on the BPNS cannot be halted. By combining both views and all available information we can judge the sustainability of dredge disposal. If this approach is applied to all human activities on the BPNS, we will have made a giant step towards sustainable management of our marine ecosystem.

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Spatial correlation between macro-fauna, vegetation structure and soil conditions in tropical coastal forest

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The structure of mangrove ecosystems is affected by various abiotic factors (temperature, salinity, nutrient availability, tidal range, topography, etc) and biotic factors (intra and inter-specific competition, fauna, anthropogenic pressure etc.) (Lee, 1999b). Faunal impact is largely due to the crab activities (Cannicci *et al.*, 2008). Some authors refer to 'crabs' as mangrove ecosystem keystone species (Smith III *et al.*, 1991; Schories *et al.*, 2003). They contribute actively to the forest structure through two activities: 'engineering' activity (Bartolini *et al.*, 2010) and herbivory behaviour (Schories *et al.*, 2003). Burrows and galleries in hypoxic or anoxic soils allow a better soil oxygenation and increase the bioavailability of nutrients such as nitrogen and phosphorus (Smith III *et al.*, 1991). In addition, some families of herbivorous crabs are known to be a threat to natural and artificial mangrove regeneration (Dahdouh-Guebas *et al.*, 1998) and a regulator of competition in high stand density areas (Bosire *et al.*, 2005), both through consumption of mangrove propagules and juveniles. We focus this ongoing study on the impact of herbivorous (Sesarmidae) and detritivorous crabs (Ocypodidae) on mangrove propagule establishment and growth in Gazi Bay, Kenya. To estimate this impact, we will first measure the correlation between floristic data (tree density, strata (canopy height) number, individual sylvimetric characteristics and specific composition), faunistic data (specific composition and density) and abiotic data (soil texture, oxygen level, acidity, nutrients bioavailability, organic matter and salinity) in contrasted areas.

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Addressing emerging issues in marine metal ecotoxicology with novel analytical techniques

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Two emerging issues in marine metal ecotoxicology are (1) the relative importance of animal physiology (elemental homeostasis) towards metal toxicity in transitional waters with intermediate salinities and (2) metal mixture toxicity. For both issues a mechanistic understanding of metal and element homeostasis upon mixture exposure is needed to enhance fundamental knowledge and applied risk assessment procedures. This study aimed at assessing the physiological impact of metal (mixture) toxicity on the homeostasis of essential elements. We used micro X-ray fluorescence (XRF) techniques to analyse mussel gills.

Gills of mussels (*Mytilus edulis*) of approximately 1.5cm, exposed to a control or copper contaminated artificial seawater, were dissected and (a) immediately cryogenically frozen on-site or (b) dehydrated in a graded aceton:water series and fixed with hexamethyldisilazane (HMDS). Elemental distributions were analysed with synchrotron based micro-XRF. In a second series of experiments, mussels were exposed to different salinities and Cu concentrations, upon which HMDS-embedded gills were analysed with laboratory source based micro-XRF. In a proof-of-principle experiment to study metal mixture toxicity, small *M. edulis* were exposed for 48h to one of the following treatments in artificial seawater (i) control, (ii) 100µg.l^{-1} added Cu, (iii) 1mg.l^{-1} added Zn or (iv) a mixture of 100µg.l^{-1} Cu and 1mg.l^{-1} Zn. Again, HMDS-embedded gills were analysed with laboratory source micro-XRF.

Preliminary results indicate that the internal distribution of metals in mussel gills at the micro scale is not significantly affected by the dehydration and HMDS fixation and enhanced tissue preservation, compared to the cryogenically prepared samples. Gills of mussels exposed to 40µg.l^{-1} Cu at a salinity of 32psu exhibited a decrease in K content compared to the control. Analyses of mussel gills exposed to salinity and combined Cu/salinity stress are ongoing. As an example of differences in elemental homeostasis between single metal (Cu or Zn) and mixture exposed mussels, this K depletion upon Cu exposure was present to a lesser extent upon Zn exposure, but was absent upon exposure to the mixture.

Micro-XRF can provide fundamental mechanistic knowledge about physiological effects of metal mixtures or metal toxicity in transitional waters. It revealed different physiological consequences of metal mixture exposures compared to single metal exposures.

Plastic waste in the Belgian coastal waters: where and how much?

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In recent years, the numerous reports about the Great Pacific Garbage Patch have raised the concern about marine litter. Some types of marine debris, notably plastics, are known to degrade very slowly and as a consequence they remain in the marine environment for a long time. This waste affects the marine ecosystem in several ways, e.g. by entanglement of wildlife or ingestion of plastics by seabirds. Another issue is that, due to the impact of currents, waves and UV radiation. larger parts of plastic debris eventually break down to smaller parts known as microplastics.

In a unique research effort through the Belspo-sponsored AS-MADE project, we monitored marine litter in the Belgian coastal ecosystem in three environmental compartments: the beach, the sea surface and seafloor. Macro debris was monitored at four different types of beach (natural or touristic, prone to sedimentation or erosion) on a 100m stretch of the beach (according to an OSPAR protocol). Microplastics in the upper (top 6 to 9 cm) sand layer were collected with a shovel or sediment core. For the sea surface, floating macro debris was collected with a neuston net, by dragging it for 1km stretches from the RV Zeeleeuw at different locations. Microplastics were analysed in two samples of 10 l seawater collected at different sites in coastal waters. Finally, macro debris was collected on the seafloor using a beam trawl, while microplastics were extracted from sediment samples, collected with a Van Veen grab.

On the beaches, the quantity of macroplastics found ranged from 0.6kg.km^{-1} to more than 5kg.km^{-1}. In terms of number of objects found, industrial pellets were very abundant at some sites, i.e. up to 93% of all collected beach plastic. On the sea surface, approximately 5 to 8.5 plastic objects were found per sampled km (i.e. on average 3,333 items.km^{-2}). The sea floor monitoring revealed the presence of roughly 1,700 to 6,500 items per km². Expressed in mass units, this amounts to 1.1kg.km^{-2} on the sea surface and 0.75kg.km^{-2} on the sea floor.

Concerning microplastics, we observed approximately 23kg.km^{-2} in the sediment of beaches and the seafloor and 7kg.km^{-2} in the water column.

In conclusion, this first monitoring exercise of macro- and microplastics in Belgian coastal waters revealed that macroplastics are mainly found on the beach. In terms of total plastic mass in the water column and in the seafloor sediment, microplastics represent a much larger quantity of plastic than the macro debris. Hence, these microplastics should not be neglected in the environmental health assessment of the Belgian North Sea ecosystem.

Can we protect our coastline and the beach ecosystem at the same time?

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Whether we like it or not, the climate is changing. An increase in storms and rising sea levels are particularly problematic for low lying countries like Belgium. Every kilometer of our coastline is intensively used and densely populated. Coastal protection against erosion and flooding is as such absolutely indispensable. Soft coastal defence techniques like beach nourishment might help to solve the problem. The word 'nourishment' means supplying a beach with sand because its sand has either flown away with the wind or got washed off with the waves. As it safeguards the natural dynamics of the coast, beach nourishment has rapidly become a widely applied protective measure in Europe. Although beaches are often regarded as barren deserts, nothing can be further from the truth. Underneath the surface lies the world of the benthic organisms. The macrobenthos are the seafloor inhabiting benthic forms larger than one millimeter. They play a key role in the wider beach ecosystem, being part of the diet of intertidal birds and fish.

Our research aims at unravelling the in-situ ecological effects of beach nourishment on the soft-sediment macrobenthos. We focus on Lombardsijde beach as it was nourished from March until September 2009, under optimal conditions. It can be regarded as a prototype of ecological beach nourishment. Approximately 650,000m³ of sand was deposited on top of the beach over a distance of around 1,200m. The sand (grain size: 200-250µm) originated from the new fairway to Ostend. The soft substrates of Lombardsijde beach have been and are being extensively monitored since 2004. Comparing the status of the beach before (t0 situation) and after (t1 situation) the nourishment provides us with the necessary answers. To distinguish the effects of beach nourishment from those of natural variation, we included control sites in our monitoring studies. The control site for Lombardsijde beach is the beach in front of Nieuwpoort-Bad.

We discovered that Lombardsijde beach has changed between 2006 and 2010. Most changes took place during and directly following the nourishment with a clearly visible peak value for abundance (intertidal: 6±1species; subtidal: 16±2species), density (intertidal: 745±247individuals.m^{-2}; subtidal: 13125±3597individuals.m^{-2}) and biomass (intertidal: 0.7±0.1g.m^{-2}; subtidal: 85.2±17.0g.m^{-2}) during autumn 2010. Unlike previous years, we also found significant differences between the intertidal median grain size of Lombardsijde and its control site. The beach profile of Lombardsijde was altered in such a way that it resembles the beach profile of Nieuwpoort-Bad almost perfectly. No other distinct negative trends for the macrobenthos were found one year after ecological nourishment.

Groundwater quality distribution in the Belgian coastal plain: a story of Holocene transgression and human intervention

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Groundwater quality distribution in coastal plains is in many cases complex and determined by many factors acting on different (time) scales: geological evolution of the coastal plain, climate, hydraulic and geochemical properties of the subsurface and human intervention. This applies also for the Belgian coastal plain where we come across a complex fresh-salt water distribution in the Quaternary phreatic aquifer.
This fresh-water distribution was studied intensively in the last 50 years resulting in for instance the well-known map depicting the depth of the fresh-salt water interface of De Breuck *et al.* (1974). Since the publication of this map, many new data has been collected going from specific studies to results from monitoring networks. This data has been used recently to revisit the fresh-salt water distribution in the central part of the coastal plain (between Nieuwpoort and Zeebrugge) (Vandenbohede *et al.*, 2010). Also the detailed geochemistry of the pore water was studied (Vandenbohede and Lebbe, in press a) for this study area.
Only minor differences with regard to the fresh-salt water distribution mapped by De Breuck *et al.* (2010) were encountered. This shows that the distribution has not undergone considerable evolutions over the last 35 years. Or it means in general that the fresh-salt water distribution is currently in equilibrium with the stresses (e.g. water levels in ditches and canals, recharge, etc.). This situation is also confirmed by simulations of the fresh-salt water evolution in the coastal plain (e.g. Vandenbohede *et al.*, in press b). Notable exceptions are areas where recent and important infrastructural interventions have taken place (e.g. large pumping for building sites, etc.).
Hydrochemistry of the pore water is determined by the displacement of saline by fresh water or vice versa. This triggers typical reactions such as cation exchange and carbonate dissolution. Additionally, a number of redox reactions such as oxidation of organic material is also important. Fresh water lenses in the aquifer are mainly the result of human intervention: impoldering led to a displacement of the older saline water by fresh recharge water. Whereas this last 1000 years is thus typified by freshening, both signatures of freshening and salinization are found in the older saline water. It is a relic of the complex Holocene transgression history: there were successive phases where saline North Sea water had a different influence on the aquifers recharge. Consequently, geochemistry and combination of flow and geochemical modelling can add to the knowledge of our coastal plains evolution.
Understanding the chemical status in a coastal aquifer and the processes determining it is a prerequisite for effective and sustainable management, especially when recognising future challenges posed by climate change. Increasing sea level changes the sea boundary of the coastal aquifer. Changing climatic parameters means that recharge patterns will change. Both will influence for instance the drainage system and hence influencing an important boundary condition of the groundwater system: fresh-salt water distribution and water quality will change in the future (e.g. increased salt load to the polders).

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Thermal niche evolution in the marine diatom genus *Cylindrotheca*

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To what extent closely related species are similar in their ecological niches is a major and recurring theme in evolutionary biology and ecology (Wiens *et al.*, 2010). Two extremes along a continuum of niche evolution can be distinguished: phylogenetic niche conservatism (PNC) and adaptive radiation (Ackerly, 2009). PNC is the tendency of species to retain aspects of their fundamental niche over time. Adaptive radiation can be defined as the evolutionary divergence of members of a single phylogenetic line into a variety of different adaptive forms. Given the paucity of data, it is at present not known how important PNC is, and more importantly to what degree organismal or environmental features influence the incidence of PNC.

Our views on evolutionary niche dynamics are biased towards macroscopic and often eye-catching species mainly from terrestrial communities; a selection often guided by natural history observations on striking ecological differentiation. Little is known about evolutionary niche dynamics in marine microbial species (Palumbi, 1994). Marine microbial populations are often believed to lack geographical barriers to gene flow (Cermeno and Falkowski, 2009) which would frequently lead to the dispersal of large numbers of cells into unfavourable environments. It has been hypothesized that marine communities are characterized by a widespread occurrence of ecological speciation, i.e. reproductive isolation caused by divergent natural selection (e.g. Ingram, 2011), but the importance of this mechanism is unknown in marine microbial communities.

We addressed the evolutionary niche dynamics within the globally distributed marine diatom genus *Cylindrotheca*. We collected strains from a wide range of marine habitats, from coastal plankton to sea ice and intertidal mudflats. We first inferred the evolutionary relationships of these strains using a multi-locus DNA dataset and obtained a well-resolved phylogeny. We then determined temperature preferences of these strains. Combining the molecular phylogeny with the thermal niches of lineages revealed a very weak phylogenetic signal in thermal niche characteristics. This indicates that closely related species tend to differ more in thermal niche than expected by a Brownian motion-based model. This seems to be caused by a combination of adaptive evolution and frequent shifts in environments in related lineages.

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A gridded archive of remote sensing data for Belgian waters

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Polar orbiting satellites with high quality moderate resolution, multi-spectral sensors have been capturing the state of the world's oceans for almost fifteen years. Here we present an archive of all data available for the Belgian waters and the Southern North Sea (50.8˚-52.1˚N; 0.5˚-4.0˚E) from the SeaWiFS, MODIS Aqua and MERIS sensors, collocated on a common one kilometre grid (details on gridding and data processing given in Vanhellemont *et al.*, 2011; Vanhellemont and Ruddick, 2011). Parameters that can be derived from the colour of the ocean include chlorophyll *a* concentration, turbidity and total suspended matter concentration (Nechad *et al.*, 2009; 2010), and more recently the attenuation of light and photosynthetically available radiation (PAR) in the water column (Lee *et al.*, 2005, Wang *et al.*, 2009) and euphotic zone depth (Lee *et al.*, 2007). Thanks to bands in the thermal infrared, MODIS can also be used to determine sea surface temperature.

Time-series of these parameters can be extracted from the archive for any point in the region. Multi-temporal composites can be generated for different periods or seasons, and even across years. Match-ups with in situ data varying in space and time, such as underway data collected by research vessels or given sample locations, can be readily extracted and used for validation.

Time-series and composites reveal an annual spring phytoplankton bloom, followed by moderate chlorophyll concentrations throughout summer and autumn. Spatial variability of the spring bloom reflects the nutrient distribution at the end of the winter, with highest concentrations near-shore. The satellite data shows considerable inter-annual variability, for example for spring bloom timing and amplitude. Suspended matter concentrations also show a strong annual cycle, with highest concentrations in winter, related to wind-induced resuspension. Spatial variability of the suspended matter is highly correlated to water depth. The sea surface temperature shows a strong annual cycle, obviously related to solar heating. Spatial variability is strongest in spring and autumn, due to differences in water depth of the near-coast and offshore waters, i.e. shallow waters heat and cool faster. The inter-annual variability of sea surface temperature is also analysed.

A dataset of this scope is useful for sediment transport and ecosystem modelers, but also for monitoring, management, and general marine science. The data archive is available for any interested parties, and an extraction interface for time-series is provided on our website.

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The Coastal Atlas Flanders/Belgium: an interactive data-driven atlas

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The Coastal Atlas Flanders/Belgium was first published in hardback in 2004 to respond to the EU Recommendation on ICZM, with no intention to move towards a web version. The many requests for maps encouraged the developers to launch a web-based atlas in 2005. The interactive nature of the maps was kept simple.

In June 2011, the Coordination Centre on ICZM launched a new web version, this time a more interactive data-driven atlas. The final product has become a portal for the Belgian coast and sea, backing the ICZM process for a wide range of coastal actors, planners and managers. It provides core information through an interactive website, to help local citizens, stakeholders and policy makers make better decisions or gain a better understanding of the coast. Great attention has been given to an attractive lay-out and the ease of navigating through the website. The information is thematically ranged in 13 chapters, taking the land-sea interface into consideration. Each chapter provides static, ready-to-use maps, coastal data and an interactive map. All static maps can be downloaded in PDF format; the data in excel format. The interactive map contains tools as measuring, zooming, printing and downloading which makes personalised maps possible. The shape files are available for download. Also, the sustainability indicators are integrated in the Coastal Atlas; 21 indicators are grouped in 7 chapters, giving an insight about the state of the coast and the sustainability of its development. Some indicators can be visualised geographically on the interactive map, in this way showing differences between regions, trends and patterns. The Coastal Atlas is available in 4 languages:
www.kustatlas.be
www.coastalatlas.be
www.atlascotier.be
www.kuestenatlas.be

In September 2011 the Coordination Centre published a second hardback version of the Coastal Atlas Flanders/Belgium with new maps, photographs and additional chapters in Dutch and English.
The Coastal Atlas Flanders/Belgium has been realised with the technical support of the Task & Finish Group Coastal Explorer, the Flanders Marine Institute (VLIZ) and developers Aquaterra and Quoted, and was financially supported by the Interreg IV A project C-SCOPE and the partners of the Coordination Centre.

Keywords: atlas; coast; indicators; interactive; sustainability.

Salinity in the Belgian coastal zone

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Ecological and morphological studies in the Scheldt Estuary rely on correct salinity distributions within the estuary, and thus an accurate description of the salinity in the coastal zone is needed. The distribution and variability of the salinity of the Belgian coastal waters is influenced by the freshwater discharges of the major European rivers discharging in the Southern North Sea, and the circulation in the North Sea. The importance of the major rivers (Scheldt, Rhine/Meuse and the Thames) is investigated with passive tracers in the CSM (Continental Shelf Model) and ZUNO (ZUidelijke NOordzeemodel) models (RWS-Waterdienst & Deltares). Furthermore the reaction of the salinity distribution to storms and large freshwater discharge events is evaluated.

Flanders Hydraulics operates a series of nested models for research purposes (hindcast) in the North Sea. The models run on the parallelized SIMONA WAQUA shallow water flow solver (SIMONA, 2009). CSMv5 has a Cartesian grid in spherical coordinates with a resolution of 1/8° longitude (9.3-6.5km) and 1/12° latitude (9.25km). The astronomical boundary conditions consist of 11 tidal components. ZUNO has a curvilinear grid with a resolution of 1-4km in the Belgian coastal zone. The models are linked with water level boundaries.

Passive tracers allow the identification of the water masses in front of the Belgian Coast. The water originates mainly from the Channel (+-96.6%) with freshwater input from the Rhine/Meuse river system (+-2.6%) and the Scheldt (+-0.5%). This is in agreement with the residual transport in the North Sea and previous research of Lacroix (2004). A region of fresh water influence is formed in front of the Belgian and Dutch coast. This mass of brackish water can expand or shrink and move under the influence of the surrounding hydrodynamics and the varying input of fresh water.
The model data is validated with a salinity dataset of 2009 (Meetnet Vlaamse Banken and HMCZ). The effect of wind events and river discharge is investigated in 4 simulations of the year 2009. Four different combinations of wind (HIRLAM/residual field) and discharge (static/dynamic) are applied in these simulations.

A period with a large discharge of fresh water results in a slow decrease of salinity in front of the Belgian coast whereas wind events have a much faster effect. Certain wind events can generate large jumps in salinity of several ppt in the Belgian coastal zone. These jumps are also observed in the measurement data. A wind event can move the entire brackish water mass or compress it much closer to the coast.

This study has contributed to the knowledge of the factors influencing the salinity distribution in the Belgian coastal zone. This knowledge is important to create adequate boundary conditions for the models of morphology, ecology and sediment transport in the Scheldt Estuary.

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Aquaculture and immunostimulation through the eyes of *Artemia*

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Diseases still cause unpredictable and high mortalities in intensive crustacean culturing, leading to major economic losses. Controlling diseases has traditionally been done using antibiotics; however, resistance is now a major problem and they became a threat to human health and environment. To obtain a more sustainable production, new strategies for controlling pathogenic bacteria are necessary; for example immunostimulation and priming (the induction of resistance in the host organism using natural signaling molecules, i.e. immunostimulants). Immunostimulants, products derived from yeast or bacterial components, are widely used for aquaculture purposes. However, the efficacy of these compounds is not yet sufficiently validated, as are effects on the host organism and possible long-term effects (Smith *et al.*, 2003). A simple model system using animals reared in a germ-free environment or with a known microorganism community (a gnotobiotic system), has been shown to be instrumental in studying immune effects. An excellent candidate for such a gnotobiotic model system is the crustacean *Artemia franciscana*, being a small and robust animal with a short life cycle. Larvae of *Artemia* are an important live-food in fish and shellfish larviculture and ingestion of pathogenic microbes may have dramatic consequences for both *Artemia* as animals that prey on them. For exploring the phenomenon of priming and immunostimulation a gnotobiotic system is being developed during this PhD project using axenic *Artemia franciscana* and a pathogen is being identified to perform challenge tests at different points in the life cycle. *Vibrio campbellii* LMG21363 is a known opportunistic pathogen for *Artemia* and is currently used as a standard strain for challenge tests using instar II nauplii of *Artemia*. Recently, there are newly identified pathogenic strains of *Vibrio* available of which our preliminary results showed at least one of them has a significantly higher virulence than the LMG21363 strain of *Vibrio campbellii*. Expected results from ongoing experiments will reveal more information about this strain, giving us a better understanding if it is better suited for challenge tests at different points in the life stage of *Artemia* compared to the standard *Vibrio* strain. It is anticipated that these experiments will also provide us information that will allow us to explore the immune response of gnotobiotic *Artemia* adults in future experiments, thus contributing to the discussion of immunostimulants for aquaculture purposes.

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Identification of the mating type locus in pennate diatoms

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Diatoms form one of the most diverse and productive groups of algae, with an estimated 200,000 species responsible for more than 1/5 of the world's primary production. They are also very interesting from a biotechnological point of view, with huge potential for the production for high-value bioproducts such as lipids, pigments and biofuels. Diatoms have a unique diplontic life cycle characterized by gradual size reduction which ultimately leads to programmed cell death. The latter, which can lead to loss of strains and cultures, can only be avoided by sexual reproduction, which enables cell size restitution via a specialized type of zygote, called the auxospore. Sex is cell-size activated, i.e. it can only be induced below a species-specific size threshold. Despite these unique features, not much is known about the molecular base of sexual reproduction and sex determination in diatoms. We are currently identifying the sex determination system of the pennate diatom *Seminavis robusta.* Crossing two strains resulted in a F1 mapping population containing 116 offspring. The segregants were analyzed with 54 *Eco*RI+2/*Mse*I+3 AFLP primer combination resulting in 500 AFLP markers. Overall, we identified 15 MT- and 13 MT+ linkage groups from the analysis of 500 AFLP markers, covering 1549 and 1418 cM, respectively. Five putatively homologous linkage groups, including the sex-linkage group, were identified between MT- and MT+ linkage groups. Currently, we are identifying the MT locus by complementing the AFLP linkage mapping by a Bulked Segregant Analysis (BSA), in combination with high throughput sequencing.

We will identify sequence alterations between plus and minus mating types and map them on the genome sequence of *Seminavis robusta* which will be available soon (Bones A., Norwegian University of Science and Technology).

In the near future, we will perform a functional characterization of the MT genes by RT-PCR and genetic transformation. The evolution of the selected MT locus genes will be studied in related diatom species. This will allow us to further investigate species formation in diatoms.

Reducing overtopping risks in Belgian coastal towns

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A masterplan to strengthen weak links in the coastal defence line in Belgium was established and approved by the Flemish government in 2011 (Vlaamse Overheid, 2011). One of the measures outlined in this plan is to reduce the overtopping risk to Belgian coastal towns by introducing programs of beach nourishment and construction of wave return walls on top of existing seaside promenades. During extreme storm conditions a high, broad beach, maintained via beach nourishment, dissipates a large part of the incoming storm wave energy. The remaining wave energy reaching the coastal revetment is reflected back offshore by the wave return wall. Construction of a wave return wall on top of the seaside promenade can limit the impact of the overtopping risk to buildings and people living in coastal towns.

To test and optimise wave return wall designs, wave overtopping tests were performed in a fixed bottom physical hydraulic model at Flanders Hydraulics Research laboratory. Tests were performed at 1:25 scale in the large wave flume with dimensions 70m long, 1.4m high and 4m wide. The foreshore profile in the scale model represents a beach profile eroded post an extreme storm event. The geometry of this eroded beach profile was estimated before construction of the physical model using the DUROSTA numerical sediment transport model.

Important processes studied with the physical hydraulic model are the transformation of waves in the breaker zone; the generation of surf-beat phenomena and their associated long wave motion on the shallow foreshore; mean and instantaneous wave overtopping; and the effect of wave return geometry at reducing impact forces and pressures on buildings to be protected behind the wave return wall.

Experimental results reveal the importance of both beach nourishment and wave return walls for safeguarding buildings and people living on seaside promenades in coastal towns. The physical model proves to be a valuable tool in the design of the coastal defence works.

In addition, data from the physical model has been used to validate a numerical model using the public domain software SWASH developed by Delft University of Technology (Zijlema *et al.*, 2011 and Suzuki *et al.*, 2011). Results show that the SWASH model gives excellent results regarding wave transformation on the very shallow foreshore. Wave overtopping can also be simulated with reasonable accuracy with this numerical model for wave walls with simple geometries. However, more complex wave wall geometries, such as a wave wall with a parapet or a stilling wave basin arrangement, cannot be represented well in the numerical model.

This work is co-financed by the European Union, via the Interreg IVb North Sea Region project SUSCOD (www.suscod.org). In this framework, model simulations are visualised to enable informed discussions with stakeholders so that a design which balances safety, aesthetic and practical requirements is achieved. This is a way to improve the implementation of Integrated Coastal Zone Management (ICZM) principles into practice, which is the overall goal of the SUSCOD project.

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Did the use of TBT-based antifouling paints cause severe damage to the common shrimp (*Crangon crangon*) population of the Southern Bight?

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The organometal tributyltin (TBT) is a potent biocide that has been used ubiquitously in antifouling paints since the 1970s. The clearly visible adverse effects (i.e. imposex and intersex) on marine gastropod populations urged the EU and IMO to adopt measures to reduce and finally ban the use of TBT-based antifouling paints on ships in 2003. Along the coast of the Southern North Sea, the common shrimp (*Crangon crangon*) is a famous regional delicacy which dominates the inshore benthic communities. Landing and effort data of the Belgian fishing fleet (Redant and Polet, 2002) reveal that the local shrimp stock has strongly decreased since the 1970s until 2003, hampering the viability of the Belgian shrimping fleet. Several potential causes have been proposed, of which a decreased areal of nursing grounds (i.e. marshes and creeks) seemed the most likely. But surprisingly, recent landing and effort data reveal that the local shrimp stock quickly recovered since 2007, reaching a historically high level in 2010. Coincidently, environmental TBT concentrations had been strongly decreasing during the last decennium, mainly due to the TBT ban. *In vitro* research reveals that TBT interferes in the signaling of shrimp nuclear receptors (Verhaegen *et al.*, 2011), which are the molecular targets of several vital hormones (e.g. steroids). Unfortunately, end-point physiological effects of the environmental TBT concentrations cannot be determined through the classical approach (i.e. long term laboratory exposure) due to a poor survival of shrimp under captivity. Physiological effects however are regulated by gene expression, and modern molecular techniques such as microarrays allow the quantification of gene expression. Hence, short term laboratory exposure at environmental TBT concentrations, and subsequent gene expression profiling using a shrimp specific microarray, (should) reveal that TBT indeed had a significant impact on shrimp endocrinology prior to the TBT-ban in 2003.

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The Belgian Register of Marine Species - BeRMS

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Although Belgium is the smallest North Sea country with the shortest coastline (± 67 kilometers) and a continental shelf of 3,457 km^2, it has a long history of marine research in which scientists try to understand its diversity and complexity. A first step towards understanding is to obtain an idea of the species diversity within this area, in other words, to establish an inventory of the local marine species. In 2010, the Flanders Marine Institute undertook efforts to compile a species list for the Belgian marine waters.

Information was extracted from already existing inventories and databases of the North Sea and a new literature search was started to further complete the Belgian marine list. A large network of experts – both taxonomic experts of the World Register of Marine Species and field experts – have joined forces to check the quality and content of the list. Of all species once documented for the Belgian part of the North Sea, the taxonomy and geographical distribution was verified. After this thorough analysis, some species were now known to be 'extinct in Belgian marine water' or are only appearing sporadically and labeled as 'vagrant'.

For some species groups, Belgian research is rather limited or just getting started. Although they are being described in literature as 'present in the Belgian marine waters', their presence in our area cannot (yet) be confirmed. For other groups, there is still a lot of discussion going on concerning the taxonomic status, which is why we decided not to include them in the Register just yet. The above mentioned situations lead to exclusion of the following groups from the Register: Bacteria, Protozoa and Bacillariophyta or diatoms.

Although it is obvious that this Belgian marine species list is not yet complete, this is so far the most complete list ever presented for this region. So far, only species currently or historically occurring in the marine environment up till (but not including) the coastal dune front are included. Future efforts will be undertaken to list all known species of the coastal zone, including the salt marshes, mud flats, dunes and the adjacent brackish areas.

The Belgian Register of Marine Species is available as a regional sub-list of the World Register of Marine Species (www.marinespecies.org/berms) since 2010. Recently, VLIZ also made Dutch web pages available, aimed at a broader audience (www.vliz.be/vmdcdata/berms). Starting from a general overview page – listing known larger taxonomic groups – a simple click leads to more information on that group and an overview of the documented species – with a Dutch name where available and pictures.

Currently (January 2012), 2,205 species are documented to occur (or have occurred) in the Belgian marine waters.

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Does alternative stable states theory and catastrophic shift theory apply for bare intertidal flats and vegetated marshes?

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The vegetation of intertidal marshes provides important ecosystem services to coastal societies, such as the reduction of wave-induced coastal erosion and attenuation of landward flood propagation during storm surges. These positive effects of intertidal marsh vegetation may change in time, because intertidal areas may shift from bare mudflats to vegetated marshes or vice versa. It is therefore important to allow the understanding and prediction of pending shifts between bare and vegetated states of intertidal areas. The concept of catastrophic shifts between bare mudflats and vegetated marshes has been explored only recently by numerical modeling and up to now only few empirical evidence has been presented in the literature. In our study, we tested the hypothesis that bare tidal flats and vegetated marshes can be considered as alternative stable landscape states with the occurrence of rapid catastrophic shifts between the two stable states. We studied this by analyzing a detailed historical record of intertidal elevation surveys and aerial pictures from the Westerschelde estuary (SW Netherlands). We examined the bimodal distribution of elevations in the intertidal areas. We tested the rapid elevation shifts from bare flats to vegetated marshes. Finally, we studied whether we can predict such shifts based on the intertidal elevation. Our results indicated that vegetated intertidal marshes lie within a small range of high elevations, while bare intertidal flats dominate a different range of lower elevations. The intermediate elevations are less frequent. Analysis of the areas that shifted from bare flats to vegetated marshes revealed that the shifts occur relatively rapid and that the shifts always seem to have occurred once the peak of the elevation distribution had exceeded a threshold value around -0.6m. Study of pioneer patches in 2004 showed that most of pioneer patches occurred in the elevation range of -0.8 m to -0.4 m, which includes the aforementioned threshold elevation where the system shifts from bare to vegetated states. Probability maps were constructed as a prediction for the shift from bare to vegetated state. The success of prediction is highly different for the onshore and offshore flats. A high probability on the onshore flats mostly results in a shift to vegetation by the next time step, while not necessarily on the offshore flats. In conclusion, our results indicate empirical evidence for the application of alternative stable states theory and catastrophic shift theory in intertidal ecosystems.

An ecosystem approach to fisheries: the seabob shrimp in Surinam

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Marine fisheries are often known to cause collateral damage to the ecosystem through bycatch and habitat destruction. As traditional fisheries management only considers the target species population, an ecosystem approach to fisheries is needed, and gains interest. Ecosystem-based fisheries management strives for an ecologically sound resource conservation responding to the reality of ecosystem processes, but implementation remains difficult. Studying the coastal zone of Surinam (South-America) the current PhD research aims to build ecological knowledge supporting ecosystem-based management for the exploitation of seabob shrimp.

The Atlantic seabob *Xiphopenaeus kroyeri* (Crustacea: Penaeoidea) (Heller, 1862) is a shrimp species with a broad distribution in the western Atlantic ocean. In line with a widely observed growth and mechanisation of tropical shrimp fleets in recent decades, industrial exploitation of seabob of the Surinam coast began developing in 1996 with the introduction of shrimp trawlers. The mobile fishing gear used by these vessels is low-selective and produces lots of non-target bycatch, mostly discarded back to the sea. Under international pressure, the use of turtle excluder devices became mandatory, drastically reducing marine turtle bycatch. Further improvements in this fishery were made in recent years by introducing a harvest control rule, a restricted fishing area, a vessel monitoring system and applying the FAO code of conduct. Despite this progress, knowledge on the marine coastal ecosystem in Surinam is lacking and the ecological impact of shrimp trawling is largely unknown.

In this study, occurrence and migration of the seabob shrimp will be studied in relation to environmental factors, mainly freshwater river outflow which is known to profoundly alter the coastal waters. Next, a food web study will be done to assess the trophic role of seabob in the ecosystem and hence the possible consequences of its large-scale removal by fisheries. A third goal is to quantify the impact of bottom trawling on the benthic ecosystem by comparing trawled and untrawled seabed areas. Finally, research results will be integrated into practical, though ecologically sound management advices for the fishery sector. As the research is from the start supported by both the fishing industry and the government authorities in Surinam, adaptation of an ecosystem approach is likely in the future. This should allow for a sustainable exploitation of the seabob, assuring both the continuation of an important socio-economic activity and the supply of a considerable domestic protein source in Surinam.

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Fundamental niche of the trees in mangrove forests

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Understanding the immense complexity of the interacting processes that determine biodiversity, productivity and functioning of mangrove ecosystems still is a major challenge. For this reason, we want to contribute expanding the knowledge about the fundamental niche of species in a mangrove. Our aim is to model the fundamental niche of the main species trees in the mangrove of Gazi Bay, Kenya.

The methodology consists in collecting biotic and abiotic information in the mangrove, integrate it in a Geographical Information System (GIS) and analyse this information in the light of species distribution modelling. In species distribution modelling two sets of input data are required: occurrence data and spatial information on the environmental characteristics of the species habitats. The species distribution modelling techniques are widely used by researches in rainforests.

All information collected in the field are going to be translated into spatial data using interpolation techniques. We are going to collect information about biotic data (such as: diameter, canopy openness, tree height, basal area, abundance, and taxonomical identification), and abiotic data (such as: soil texture, oxygen level, acidity, nutrient bioavailability, organic matter and salinity). In addition, we are going to incorporate variables like distance from of the major rivers and the sea front.

After the post-processing of the variables they serve as input data for the software Maxent. This program will be used to analyse the potential distribution of the species, in other words, their fundamental niches. In addition, we are going to use the jack-knife technique to analyse which variable will contribute more to the actual distribution of the trees in mangrove.
The expected outcome will be a spatially-explicit outline of the relation of the biotic and abiotic component in the mangrove in regard to the mangrove tree layer and to the mangrove forest in its entirety. It will allow us to describe the fundamental niches of species in the mangrove in terms of abiotic factors as well as other organisms and to deduce hypotheses of interdependence in the system.

Keywords
Mangrove; species distribution modelling; GIS; geoprocessing.

Linking microbial and macrofaunal diversity with benthic ecosystem functioning of the Belgium parts of the North Sea

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Ecosystem functioning is a broad term that encompasses a variety of phenomena and natural processes like cycling of nutrients which is influenced by fauna through functional and species diversity as well as abiotic factors. Nitrogen (N) is most often implicated as the nutrient limiting primary production in the coastal ocean. Nitrification, the oxidation of ammonia to nitrate via nitrite, is central to the cycling of nitrogen in the environment and, when coupled with denitrification, alleviates the effects of eutrophication through removal of nitrogen to the atmosphere as nitrous oxide or dinitrogen gas. Coupled nitrification/denitrification constitutes an important aspect of marine benthic ecosystem processes. It has been well-known that microbial oxidiser including ammonium-oxidizing archaea (AOA) and ammonium-oxidizing beta and gama proteobacteria (AOB) play a central role in nitrogen cycling in coastal and estuarine systems. AOA and AOB can be studied in detail by assaying their functional gene amoA. Various environmental variables (e.g. sediment type, nutrients, porosity) affect the spatial distribution of the microbial communities. In addition, macrofaunal organisms are important as well as their burrowing, feeding, locomotive, respiratory and excretory activities affect the environment on the local scale. Nevertheless, it is still unclear how ecosystem functioning rates, presence of macrofaunal organisms and diversity and activity of microbial communities are related.

Therefore, spatial and temporal aspects of the community structure of bacteria and archaea in general, and of AOB and AOA in detail, were evaluated in 7 sampling stations covering a wide variety of sediment types. Sampling was performed during the peak spring bloom (April), shortly after bloom (June) and during the period of highest mineralisation rates (September) in the Belgian part of the North Sea in 2011.

In our study we use a molecular method based on Denaturant Gradient Gel Electrophoresis (DGGE), which is a widely used method for mutation analysis and for studies of microbial diversity.
Total microbial diversity, based on the 16S rDNA gene will be assessed in order to investigate the relationships between microbial diversity and environmental factors (sediment grain size, sediment O_2, CN, porosity, sediment and water pigment concentrations and nutrient concentrations in the water column). In addition, the link between the metabolically active AOA and AOB will be investigated as well. During a series of lab incubations, fluxes of nutrients (NO_3^-, NO_2^-, PO_4^{-3}, NH_4^+) and O_2 across the sediment–water interface were measured, and will be linked with the community composition and diversity of the AOA and AOB present in these incubations.

By investigating the link between ecosystem functioning, macrofauna and the microbial communities, we close the gap that exists between marine 'macro-ecologists' (focusing on the link macrobenthos-ecosystem functioning) and marine 'micro-ecologists' (focusing on the link microbial communities-ecosystem functioning) and increase the knowledge about the mechanisms underpinning some of the important benthic ecosystem functions.

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APPLICANTS
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Tuimelaars (*Tursiops truncatus*) in Bahia San Antonio, Patagonië, Argentinië: gedrag, sociale compositie en populatieschatting

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De hoge observatiefrequentie en residentie in Bahía San Antonio (BSA), maken van dit gebied een ideale plaats voor langetermijnstudies over tuimelaars. Dit genereert een opportuniteit voor de beschrijving van de ecologie, biologie en sociale structuur van deze topzoogdier predator, wat vitaal is voor hun conservatie. Een foto-identificatie studie was uitgevoerd gedurende 33 dagen (2010) in BSA, Patagonië, Argentinië, om het gedrag, sociale compositie en populatieaantallen van de tuimelaars te onderzoeken. Dit resulteerde in 14 bootgebaseerde (9 positief) en 8 landgebaseerde (7 positief) observaties. Via deze landgebaseerde observaties kon een observatiefrequentie van 0.20/h bekomen worden. De resultaten geven weer dat de dolfijnen het meeste van de tijd aan het rondtrekken waren, gevolgd door voeden en socialiseren. Data indiceren dat de dolfijnen BSA gebruiken als een voedsel- en geboorteplaats, specifiek in de winter. De lagere populatieschatting van 66 individuen (CI 95%=64-76), in vergelijking met de schatting van Vermeulen & Cammareri (2009, ongepubliceerde data), waren een consequentie van het feit dat de locale abundantie nog niet op zijn piek was, waarbij de hoogste abundantie bereikt wordt later in het seizoen (rond September). De half weight index werd gebruikt om de coëfficiënten van de associaties te bepalen, en dit voor 10 individuen die ≥ 5 keer gezien waren in 10 ontmoetingen (waar meer dan 50% van de individuen van de groep konden geïdentificeerd worden). De distributie van de coëfficiënten van de associaties waren redelijk hoog, waar de meeste dolfijnen gemiddelde tot hoge associaties vertoonden met elkaar. Dit lijkt veroorzaakt te zijn door gedragspecifieke associaties en dit vooral tijdens het voeden, wat nog niet geregistreerd was in vorige studies gemaakt door Vermeulen & Cammareri (2009). Daarenboven, stelt het beste beschrijvende model voor dat de populatie van BSA bestaat uit snel dissociërende individuen en constante metgezellen, waarbij de gekozen associaties niet stabiel kunnen zijn tussen de verschillende observaties. De grote variatie in de groepsaantallen, de lage modulariteit en de frequente verandering in subgroup clustering indiceren dat de Tuimelaars van BSA in een fissie-fussie gemeenschap leven. De hoge observatiefrequentie, het groeiende ecotoerisme, residentie, en de waargenomen daling van tuimelaar observaties tonen het belang aan van verder onderzoek, wat vitaal is voor de conservatie van de soort.

Intertidale *Lanice conchilega* riffen als voedselgronden voor wadvogels in de baai van de Mont Saint-Michel (Frankrijk)

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Ingetijdengebieden staan er voor gekend grote hoeveelheden vogels aan te trekken door te fungeren als voedselbron, rustgebied of broedgebied. Biogene habitats binnen deze intergetijdengebieden, zoals riffen opgebouwd door de kokervormende borstelworm *Lanice conchilega*, kunnen een belangrijke rol vervullen als voedselgronden voor foeragerende vogels. De aantrekkingskracht van de *L. conchilega* riffen schuilt in de complexiteit van het habitat maar vooral in de hoge abundanties van macrofauna die kunnen worden aangetroffen in de riffen. Om de voedingsecologie, en de daarmee samengaande adaptatie van soorten aan hun habitat te kunnen begrijpen, is het noodzakelijk het belang van deze benthische gemeenschappen als potentiële voedselbron voor wad-, en watervogels te evalueren. In dit opzicht is het verwerven van inzichten omtrent de voedselsamenstelling van vogels essentieel. Deze studie stelt een evaluatie voorop van het functionele belang van *L. conchilega* riffen voor wadvogels in het intergetijdengebied van de baai van de Mont Saint-Michel (Frankrijk); een gebied dat van internationaal belang is voor migrerende vogels. Wadvogels werden zowel in de volledige baai als in de *L. conchilega* riffen geteld met het oog op het vergelijken van de gemeenschap tussen beide gebieden. Daarenboven werd door middel van fecale analyse het voedingsregime onderzocht van wadvogels foeragerend in de riffen. De samenstelling van de wadvogelgemeenschap, zonder rekening te houden met abundanties, kan als overeenkomstig worden beschouwd in beide gebieden. Het in rekening brengen van de abundanties resulteert in geobserveerde vogelfrequenties die tot 30 keer hoger zijn dan de geschatte verwachtingen gebaseerd op een uniforme verdeling van vogels over de volledige baai. Dit toont overduidelijk de attractiviteit van de riffen voor vogels aan. In de riffen voeden wadvogels zich met *L. conchilega*, maar hoge aantallen van geassocieerde macrofauna, en in het bijzonder crustacea, werden eveneens aangetroffen in de feces. Hoewel bivalvia zeer abundant zijn in het rifbenthos maken ze slechts een zeer klein deel uit van de onderzochte vogelfeces. Vergelijkingen in dieetsamenstelling tussen de wadvogels brengt kleine verschillen aan het licht die vooral te wijten zijn aan verschillen in krabben, *L. conchilega* en amphipoda. Een voedingsstrategie die zowel eigenschappen van selectieve als opportunistische strategieën combineert lijkt de regel te zijn in de *L. conchilega* riffen.

De invloed van klimaatsverandering op stormopzet aan de Belgische kust

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Deze thesis had als doel om de impact te onderzoeken van de klimaatsverandering op de stormopzet aan de Belgische kust en dit door het opstellen van een aantal stormopzetvoorspellingsmodellen.

Eerst is er een verklarende variabele gezocht die een hoge correlatie met de stormopzet heeft en waaruit deze dan ook voorspeld kan worden. De luchtdruk (met het zeeniveau als referentie) bleek deze hoge correlatie te hebben, zeker in de regio van de zuidelijke Baltische zee, rond de kusten van Polen, Estland, Letland en Litouwen.

Om de relatie tussen de luchtdruk en de stormopzet verder uit te spitten werden twee classificatiemethodes gebruikt: het classificatiesysteem van Lamb (geautomatiseerd door Jenkinson en Collison) en classificatie door middel van hoofdcomponentenanalyse (of principale componentenanalyse) en 'k-means clustering'. Door het gebruik van deze methodes werd duidelijk dat de weertypes West, Noordwest en Noord systematisch een hogere stormopzet hadden, waarbij de naam van het weertype voornamelijk door de windrichting bepaald wordt (dit op basis van de locatie van hoge en lage luchtdrukvelden). Dit was ook zo voor de cluster die de naam 'Atlantic Ridge' of Atlantische rug draagt, deze cluster is een verzameling van luchtdrukpatronen die een westelijke windrichting veroorzaken.

Omwille van de grote variatie in de relatie tussen de stormopzet en de luchtdruk aan de Baltische Zee, zijn een aantal verschillende modellen opgesteld en gecontroleerd met observaties om zo het model met de beste correlatie tussen de voorspelde en de geobserveerde stormopzet te behouden. De verschillende modellen gebruiken verschillende methodes om de regressielijnen af te stemmen op de stormopzet en luchtdrukdata, zo werd bv. een lineaire regressielijn getest, alsook veeltermen van verschillende ordes. Ook is het model opgedeeld in verschillende submodellen, gebaseerd op luchtdrukintervallen of op basis van het weertype waartoe de dag behoort. De correlatie tussen de voorspelde en de geobserveerde stormopzet bedraagt 65% voor het beste model. Andere variabelen zoals de wind en het getijde zijn ook getest maar verbeteren de voorspellingsmodellen niet of nauwelijks.

Een aantal extra facetten zijn ook onderzocht, zoals bijvoorbeeld het testen van de beste modellen op een dagelijkse basis voor het vergelijken van de voorspellingen met de observaties. Ook is onderzoek verricht om de resultaten bruikbaar te maken voor het inschatten van het overstromingsgevaar in het Schelde-estuarium. Hiervoor is onderzocht wat de relatie is tussen de hoogte van een piek van de stormopzet en de duurtijd van de stormopzet boven een bepaalde drempelwaarde, alsook de relatie van de hoogte van de piek met de lengte van een consistente periode van dagen met hetzelfde weer- of clustertype. Voor dit laatste facet is een stijgende relatie gevonden voor de weertypes die hoge stormopzetten veroorzaken. Ook is gekeken naar de relatie tussen de stormopzet en de neerslag. Hoewel er een kleine stijgende relatie is tussen beide voor de hogere waarden, vallen de extremen niet of nauwelijks samen op dagelijkse basis.

Interactie van *Prorocentrum lima* met *Mytilus edulis* (2010-2011)

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Inleiding

Harmful algal blooms (HAB's) produceren toxines die niet alleen verantwoordelijk zijn voor aanzienlijke gezondheidsproblemen maar ook voor economische schade. Eén van die toxines is okadazuur (OA) dat wordt geproduceerd door verschillende *Prorocentrum* en *Dinophysis* soorten. OA bindt met proteïnefosfatase enzymen (voornamelijk PPA2 en PP1) waardoor het defosforyleren van enzymen wordt geïnhibeerd. Hierdoor krijgt men een verstoring in het cellulair evenwicht door hyperfosforylatie. Bij de mens is de dunne darm waarschijnlijk het doelorgaan. OA is daar verantwoordelijk voor de hypersecretie van de darmvilli met gastro-intestinale klachten tot gevolg (Diarrhetic Shellfish Poisoning (DSP)).

In de naam DSP wordt al verwezen naar de belangrijkste oorzaak van intoxicatie bij de mens namelijk het consumeren van schaaldieren. Er zijn al uitgebreide onderzoeken uitgevoerd naar het effect van OA bij de mens, maar onderzoeken naar het effect bij schaaldieren zijn schaars. Uit voorgaande studies weet men dat er geen stijging is van de mortaliteit bij de gewone mossel (*Mytilus edulis*) na intoxicatie met OA. Twee sublethale effecten zijn bij de mossel wel gekend. Ten eerste worden bij het *in vitro* toevoegen van OA ook de proteïnefosfatase enzymen van de mossel geïnhibeerd, maar ook *in vivo* worden deze enzymen geïnhibeerd bij een concentratie van 1,7µg $OA.g^{-1}$ hepatopancreas. Ten tweede stijgt de mortaliteit bij hemocyten na het toevoegen van OA. In dit onderzoek wordt nagegaan of de lysosoommembraan-stabiliteit (LMS) en proteïnefosfatase-activiteit daalt bij een toenemende concentratie aan *P. lima*.

Materiaal en methoden

De mossels (*M. edulis*) werden verdeeld over een controle en twee behandelingen [500 *P. lima* $cellen.ml^{-1}$ (B1) en 1500 *P. lima* $cellen.ml^{-1}$ (B2)]. De voeding en *P. lima* cellen werden eenmaal per dag toegediend gedurende acht dagen. De lysosoommembraan-stabiliteit (LMS) werd bepaald via het neutral red retention time protocol geformuleerd in ICES (2004). De proteïnefosfatase-activiteit werd bepaald door na te gaan hoe snel P-nitrofenylfosfaat (pNPP, kleurloos) gedefosforyleerd werd naar p-nitrofenol (geel) door de aanwezige enzymen. Naast het *in vivo* experiment werd ook een *in vitro* experiment uitgevoerd. In dit experiment werd een OA-standaardreeks aangelegd (3 replicaten). Praktisch werd de enzymactiviteit bepaald door het meten van de kleurverandering bij 405nm met een spectrofotometer. De toxine concentratie van het water (dag 8) en de mossel (hepatopancreas en restweefsel) werd bepaald met een LC-MS volgens het protocol van Bravo *et al.* (2001).

Resultaten

Er werden geen toxines gedetecteerd in het water en in de hepatopancreas van de controle. Bij de behandelingen was er zowel in het water (B1: 3,9ng $OA.ml^{-1}$; B2: 13,5ng $OA.ml^{-1}$) als in de hepatopancreas (B1: 0,22µg $OA.g^{-1}$; B2: 0,74µg $OA.g^{-1}$) een significante stijging merkbaar. In de rest van het zachte weefsel werd geen verschil opgemerkt tussen de controle en de behandelingen.

Bij het *in vitro* experiment werd een significante daling waargenomen bij 0,1ng $OA.ml^{-1}$ (2x) of 1,6ng $OA.ml^{-1}$ (1x). Wanneer de concentratie hoger was dan 0,25µg $OA.ml^{-1}$ werd telkens een plateau gevormd waarna er geen verdere daling werd waargenomen. De maximale inhibitie lag tussen 14,5 en 20%. Bij het *in vivo* experiment werd de proteïnefosfatase-activiteit niet geïnhibeerd. Er werd geen significante daling in lysosoommembraan-stabiliteit genoteerd, maar er was wel een daling van het gemiddelde en een stijging in de variatie.

Discussie

Uit de resultaten blijkt dat *P. lima* OA produceert. Deze toxines worden ook opgenomen door de mossel waar ze accumuleren in de hepatopancreas. In de rest van de weefsels werden geen aantoonbare hoeveelheden gevonden. Niettegenstaande er geen verschil in LMS werd aangetoond was er waarschijnlijk wel een effect gezien de gemiddeld lagere membraan-stabiliteit. Door de grote variatie was deze daling echter niet significant. Bij het *in vitro* proteïnefosfatase-experiment werd een duidelijke daling waargenomen en op basis hiervan verwacht men ook een daling tussen 8 en

15% bij het *in vivo* experiment. Deze daling wordt niet waargenomen wat mogelijks wijst op het bestaan van een detoxificatiemechanisme bij de geteste concentraties. Deze capaciteit is waarschijnlijk wel beperkt aangezien er merkbare gevolgen zijn bij een concentratie van 1,7µg $OA.g^{-1}$ hepatopancreas (Svensson, 2003). Uit de literatuur blijkt dat de inactivatie van OA door het binden met een lipoproteïne de meest waarschijnlijke verklaring is, maar verder onderzoek zou dit nog moeten uitwijzen.

Het belang van artificiële riffen, gevormd door windmolenparken, als voedingsgronden voor demersale vissen in het Belgisch deel van de Noordzee

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In Noordwest Europa wordt een enorme uitbreiding verwacht van offshore windenergie. Door de constructie van het C-Power windmolenpark in het Belgisch deel van de Noordzee (BDNZ) ontstond de mogelijkheid om de impact van artificiële riffen (windmill artificial reefs, WAR) na te gaan op de ichthyofauna. In deze studie werd het belang van WAR als voedingsgronden voor demersale vissen in het BDNZ nagegaan. De volgende doelstellingen werden vooropgesteld: (1) kwantificeren van het energiegehalte en de biochemische samenstelling (eiwitten, suikers en vetten) van kabeljauw en steenbolk en hun belangrijkste prooisoorten (*Jassa herdmani* en *Pisidia longicornis*) met het cellular energy allocation (CEA) protocol, (2) bepalen van het belang van de organische matten die gevormd worden door *J. herdmani* in het dieet van beide vissen en (3) berekenen van de turnover rate van prooi naar vis. Op die manier kan de populatiegrootte van demersale vissen geschat worden die kan onderhouden worden door de aanwezige epifauna op het WAR.

Gezien CEA protocols voor vissen niet beschikbaar waren, werden enkele aanpassingen aangebracht in het originele CEA protocol om betrouwbare en reproduceerbare resultaten te bekomen. Het netto energiebudget van de visstalen werd berekend uit de beschikbare en verbruikte energie (CEA = Ea/Ec). De resultaten van deze studie toonden aan dat de vissen die gevangen werden in de nabijheid van het WAR voldoende energie beschikbaar hadden voor groei en reproductie. De energiewaarden voor *J. herdmani* en *P. longicornis* waren bijna gelijk, wat wijst op hun gelijkaardige voedingswaarde. De *Jassa* matten bleken geen voedingswaarde te hebben in het dieet van de vissen.

Vissen kunnen zelf geen essentiële vetzuren (essential fatty acids, EFA) zoals EPA of DHA aanmaken, maar moeten deze verkrijgen uit hun dieet. Bijgevolg kunnen vetzuurprofielen gebruikt worden om het dieet van predators na te gaan. In dit onderzoek werden EPA en DHA in relatief grote concentraties gevonden in de dominante prooisoorten, maar bijna niet in de *Jassa* matten. In *P. longicornis* werden hogere waarden gevonden voor het vetzuur C16:1□7 dan in de andere prooisoorten, wat het belang van deze soort in het bijzonder in het dieet van de vissen weergeeft. Naast dit specifiek vetzuur en de EFA, waren de vetzuurprofielen van de vis- en prooisoorten sterk gelijkaardig,wat aantoont dat alle onderzochte prooisoorten (behalve *L. holsatus* en de *Jassa* matten) belangrijke componenten waren in het dieet van de vissen.

Omdat er geen data beschikbaar waren over de biomassa van de aanwezige prooien op het WAR, ontbrak essentiële informatie om de turnover rate van prooien naar vissen te berekenen. Bijgevolg kon de populatiegrootte van demersale vissen die ondersteund kan worden door de aanwezige epifauna op het WAR nog niet geschat worden. Daarenboven zijn meer analyses nodig om de validiteit van het aangepaste CEA protocol te bepalen. Verder onderzoek blijft dus cruciaal.

Groei en structurele veranderingen van vivipare mangrovepropagules: het effect van de omgeving op verspreiding en vestiging

Oste Jorien

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De meeste mangrovesoorten worden, naast luchtwortels en zoutregulatie en -tolerantiemechanismen, ook gekenmerkt door vivipare voortplanting. Dit wil zeggen dat hun zaden al kiemen terwijl ze nog aan de moederboom hangen. Na de kieming blijven de kiemplanten nog een tijd aan de moederboom hangen om verder te groeien en daarna worden ze verspreid. De verspreidingseenheden van deze vivipare mangrovesoorten zijn dus kiemplanten, ook propagules genoemd, in plaats van zaden. Terwijl de zaden, en later de propagules, nog met de moederboom verbonden zijn, groeit het embryo continu, zonder dormantieperiode. Tijdens een dormantieperiode wordt kieming verhinderd door bepaalde eigenschappen van het zaad. Gedurende de dormantie kunnen zaden een periode van ongunstige omstandigheden overleven, waarna de dormantie doorbroken wordt door omgevingsfactoren die voor de kieming gunstige omstandigheden aankondigen.

Eerder onderzoek toonde een mogelijke link aan tussen de vivipare voortplanting van planten en natte habitats, zoals mangroves. Toch is het nog steeds niet helemaal duidelijk wat de precieze adaptieve voor- en nadelen zijn van viviparie, die ervoor zorgen dat veel, maar niet alle mangrovesoorten zich voortplanten via viviparie.

In deze studie werden de groei en structurele veranderingen van mangrovepropagules voor en na abscissie van de moederboom bestudeerd, om volgende hypotheses te testen:

1. Een nadeel van viviparie is dat de moederboom ook na de kieming de groei van propagules nog moet ondersteunen, dit wordt gecompenseerd door de autonome groei van de propagules terwijl ze nog aan de moederboom hangen. Bovendien bedraagt deze autonome groei een hoger percentage (ten opzichte van de groei gesteund door de moederboom) bij soorten met grotere propagules (zoals *Rhizophora mucronata*) dan bij soorten met kleinere propagules (zoals *Ceriops tagal*).
2. Een voordeel van viviparie is dat de propagules die verspreid worden minder gevoelig zijn dan zaden aan de stressvolle omstandigheden waarin ze verkeren tussen abscissie en vestiging. Bovendien is er een uitgestelde dormantieperiode tussen abscissie en vestiging van de propagule, tijdens welke de propagule niet groeit, vergelijkbaar met de dormantieperiode van vele zaden.
3. Deze uitgestelde dormantie wordt doorbroken door signalen uit de omgeving, die gunstige omstandigheden voor de vestiging van de propagule aangeven en wortelgroei en dus vestiging induceren.
4. Tijdens de vestiging van propagules is de wortel- en lengtegroei en bladontwikkeling minder goed wanneer de saliniteit hoger is, en beter wanneer de relatieve vochtigheid hoger is.

Deze studie werd uitgevoerd in Gazi Bay, Kenia, waar twee vivipare mangrovesoorten, *Ceriops tagal* (Perr.) C.B Robinson en *Rhizophora mucronata* Lamk., werden bestudeerd. Beide soorten domineren de mangroven van Gazi Bay samen met de cryptovivipare mangrovesoort *Avicennia marina* (Forsk.).

Om hypothese 1 te testen werd een experiment uitgevoerd met propagules die nog aan de moederboom hingen. De helft van deze propagules werd met aluminiumfolie afgeschermd van licht, om zo fotosynthese en dus de autonome groei te verhinderen, terwijl de andere propagules onbedekt bleven (Experiment A). De groei van bedekte en onbedekte propagules werd over een bepaalde periode gevolgd en vergeleken, om zo het percentage autonome groei te bepalen en tussen beide soorten te vergelijken.

De propagules die werden gebruikt, bleken echter niet jong genoeg te zijn, waardoor velen van de boom vielen nog voor het experiment was afgelopen. Hierdoor kon hypothese 1 niet worden getoetst. Wel werd er wortelgroei vastgesteld voor propagules die aan het einde van het experiment nog aan de moederboom hingen en bedekt waren met aluminiumfolie. Dit is een opmerkelijke observatie omdat wortelontwikkeling bij propagules aan de moederboom niet voorkomt onder

natuurlijke omstandigheden. Om dit resultaat te verklaren, stellen we de volgende hypothese voor: Door gebrek aan luchtcirculatie, stapelde ethyleen, dat door alle propagules aan de moederboom wordt geproduceerd, zich op binnen het aluminiumfolie waarmee de propagules bedekt waren. De verhoogde concentratie aan ethyleen induceerde vroege wortelgroei.

Om hypotheses 2-4 te testen, werden rijpe propagules van beide soorten verzameld en in horizontale positie op de volgende substraten gelegd: droog zand, vochtige modder en zeewater (Experiment B). Deze drie substraten simuleerden verschillende mogelijke omstandigheden waarin propagules zich kunnen bevinden tijdens de periode tussen abscissie en vestiging. Om de zes dagen werden, voor beide soorten, vijf propagules van ieder substraat gehaald. Drie van deze propagules werden in een verticale positie geplaatst in drie verschillende hydroponische opstellingen. Deze hydroponische opstellingen simuleerden de vestiging van propagules onder de volgende verschillende omgevingsomstandigheden: lage saliniteit (50% zeewater), hoge saliniteit (100% zeewater) en lage saliniteit (50% zeewater) gecombineerd met verhoogde luchtvochtigheid (Experiment C).

Tijdens experiment B, werd voor geen van beide soorten lengtegroei waargenomen en wortelgroei startte ten vroegste nadat de propagules 13 dagen op een van de substraten hadden gelegen. Dit resultaat geeft aan dat, overeenstemmend met hypothese 2, propagules van beide soorten een periode van uitgestelde dormantie doormaken nadat ze van de moederboom zijn gevallen maar voordat ze zich hebben gevestigd. Voor *R. mucronata* propagules die tijdens experiment B op de drogere substraten lagen (droog zand of vochtige modder), en dus meest waren gedehydrateerd, startte de wortelgroei tijdens experiment C vroeger dan voor propagules die tijdens experiment B in zeewater hadden gelegen. Dus, dehydratatie was de omgevingsfactor die wortelgroei induceerde en de uitgestelde dormantie doorbrak. Daarentegen werden voor *C. tagal* propagules die tijdens experiment B het minst aan dehydratatie waren blootgesteld de langste wortels waargenomen. Dit resultaat geeft aan dat vochtigheid de stimulerende factor is voor wortelgroei van *C. tagal* propagules en de uitgestelde dormantie doorbreekt. Deze resultaten stemmen overeen met hypothese 3: In Gazi Bay groeit *R. mucronata* voornamelijk in gebieden met een hoge inundatiefrequentie, waar de kans groot is dat een gestrande propagule opnieuw wordt weggespoeld alvorens ze zich kan vestigen. Wanneer een propagule op een plek die minder vaak overstroomt terechtkomt, zal ze meer dehydrateren. Deze dehydratatie is dan het signaal dat aangeeft dat de omstandigheden gunstig zijn voor vestiging en zorgt ervoor dat de uitgestelde dormantie doorbroken wordt. *C. tagal* groeit vaker verder van zee, in gebieden met een lagere inundatiefrequentie, waar watertekort een limiterende factor is voor de succesvolle vestiging van propagules. Op een vochtige plek zullen propagules minder snel dehydrateren, wat gunstig is voor propagule vestiging en tegelijk ook het signaal voor het doorbreken van de uitgestelde dormantie.

Verder werd ook waargenomen dat het drijfvermogen van de propagules van *C. tagal* een duidelijk patroon volgden: eerst dreven ze horizontaal aan het wateroppervlak, waarna de oriëntatie veranderde naar diagonaal en dan verticaal met de plumule omhoog gericht. Vervolgens zonken de propagules naar de bodem waar hun positie opnieuw van verticaal naar horizontaal, plat op de bodem, veranderde. Dit patroon werd niet waargenomen voor *R. mucronata* propagules, die zich veel willekeuriger gedroegen en langer hun drijfvermogen behielden. Hieruit volgt dat *R. mucronata* propagules over een langere periode na de abscissie verspreid kunnen worden door het zeewater alvorens te zinken.

Tijdens experiment C werd ook waargenomen dat de lengtegroei van *C. tagal* propagules en de lengte- en wortelgroei van *R. mucronata* propagules het hoogst was voor propagules die werden behandeld met een lage saliniteit en hoge luchtvochtigheid. Bladontwikkeling werd enkel waargenomen voor een deel van de *C. tagal* propagules, waarvan de meeste groeiden in water met lage saliniteit. Deze resultaten steunen hypothese 4. Lage saliniteit en hoge luchtvochtigheid komen beide voor tijdens het regenseizoen in Gazi Bay, wat dus het meest gunstige seizoen is voor de vestiging en vroege groei van *C. tagal* en *R. mucronata* propagules.

Functional and structural responses of harpacticoid copepods to anoxia in the Northern Adriatic: an experimental approach

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To study the effects of anoxia on the functioning of meiobenthic communities in the Northern Adriatic, Gulf of Trieste, an *in situ* experiment was conducted. Anoxia was created artificially with the use of an Experimental Anoxia Generating Unit (EAGU). Nematodes were found as most abundant taxon, followed by harpacticoid copepods. Nematodes densities were not affected by treatment (anoxia/normoxia) nor by sediment depth. On the other hand, harpacticoid copepod densities differed significantly depending on treatment and sediment depth. Also harpacticoid copepod families composition was affected by anoxia and by sediment depth layer, but anyhow Ectinosomatidae and Cletodidae were most abundant in both normoxic and anoxic samples. In addition, the functional responses of harpacticoid copepods to anoxia were tested in a lab experiment with additional 13C prelabelled diatoms in order to test (1) if there was any difference in food uptake by copepods under normoxic and anoxic conditions and (2) whether initial feeding of copepods on diatoms could result into a better survival of harpacticoid copepods in anoxic conditions. Independent of the addition of diatoms, there was a higher survival rate in normoxic conditions than in anoxic conditions. The supply of additional food did not result into a higher survival rate of copepods in anoxic conditions. The results indicate a strong effect of anoxia on harpacticoid copepods, both on structural and functional aspects. The lack of the effect of additional food on the survival rate of copepods in anoxic conditions could be explained by the fact that grazing on diatoms by copepods stopped in anoxic conditions.

Seizoenale dynamieken in de contributie van artificiële harde substraten aan het dieet van steenbolk (*Trisopterus luscus*) en Atlantische kabeljauw (*Gadus morhua*) in het Belgisch deel van de Noordzee

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De antropogene klimaatsverandering heeft de belangstelling voor hernieuwbare energiebronnen aangewakkerd. De verhoogde implementatie van offshore windmolenparken (OWP) wordt gereflecteerd in een toenemend aantal wetenschappelijke studies, betreffende de impact van deze OWP op het mariene ecosysteem. De bekommernis gaat voornamelijk uit naar potentiële negatieve impacts, onder meer habitatverlies, geluidsoverlast en electromagnetische stralingen. Daartegenover staat de groeiende bewijslast dat OWP een positieve invloed kunnen hebben op de mariene omgeving. OWP, gesloten voor visserij, kunnen beschouwd worden als de facto mariene beschermde gebieden. Daarenboven manifesteren de OWP zich als artificiële riffen (AR), en dragen bij tot de ontwikkeling van de lokale biodiversiteit. Aanvankelijk werd gedacht dat de hoge densiteit van ichtyofauna rond de AR een indicatie was van een verhoogde productiviteit. In 1983 lanceerde men een alternatieve hypothese, die betoogt dat AR de vispopulaties uitsluitend aantrekken, zonder een verhoogde lokale productie. Deze controverse staat bekend als het "attractie-productie debat". Veel studies wijzen op de pragmatische aanwending van AR op de bevordering van een duurzame visserij. Als deze AR echter louter vis aantrekken, eerder dan de lokale productie te verhogen, kunnen deze AR overbevissing stimuleren. Zodoende is het, met het oog op het behoud van mariene biodiversiteit en duurzame visserij, cruciaal om te achterhalen of de OWP louter de vissen aggregeren of effectief voorzien in een verhoogde productie.

Vorige studies, beoogd op het vaststellen van productie of attractie, focusten voornamelijk op veranderingen in visabundantie, waarbij de trofische interacties buiten beschouwing werden gelaten. Desondanks is een eventuele conversie van AR epibenthos in visbiomassa een belangrijk gegeven om de verhoogde visdensiteit toe te schrijven aan of attractie dan wel productie. Bovendien is er een gebrek aan kennis omtrent seizonaliteit in de trofische relatie van vis met de WAR, gerelateerd met de seizoenaliteit in de epibenthos gemeenschap, gevestigd op de WAR.

Met de constructie van een windmolenpark in het Belgisch deel van de Noordzee, C-Power, gestart in 2008, biedt een unieke situatie zich aan om de effecten van artificiële harde substraten op de ichtyofauna te onderzoeken. Deze master dissertatie onderzocht de trofische relatie van steenbolk en kabeljauw met de windmolen artificiële riffen (WAR) in het Belgisch deel van de Noordzee (BPNS) en focuste meer specifiek op seizoenale fluctuaties in voedingsgedrag.

Een aantal onderzoekshypothesen werden vooropgesteld:
- De implementering van de WAR in het Belgisch deel van de Noordzee resulteert niet in een lokale toename in abundantie van kabeljauw en steenbolk.
- Er is geen significante seizoenaliteit in populatiestructuur voor steenbolk en kabeljauw aan de WAR.
- Er is geen significante spatio-temporele variatie in conditie-indices voor steenbolk en kabeljauw aan de WAR.
- Er is geen significante trofische relatie tussen steenbolk en kabeljauw met de WAR.
- Er is geen significante spatio-temporele variatie in voedingsgedrag en dieetsamenstelling voor steenbolk en kabeljauw aan de WAR.

Staalnamecampagnes werden uitgevoerd tussen maart 2010 en februari 2011, gebruikmakend van de RV Zeeleeuw. Tijdens deze campagnes werden er 3 gebieden bemonsterd: (1) windmolen D5 in het concessiegebied van C-power op de Thorntonbank, (2) de Thorntonbank zandbank als referentiegebied voor het zacht substraat en (3) een scheepswrak (LCT 457) als referentiegebied voor het hard substraat. De populatiestructuur werd bepaald aan de hand van vangstgegevens en lengtefrequenties. De conditiebepaling gebeurde aan de hand van de Fulton' s conditie-index en de hepatosomatische index. De trofische relatie van steenbolk en kabeljauw met de WAR werd onderzocht aan de hand van maaganalyses, waarbij alle voedselcomponenten geïdentificeerd werden tot op het laagst mogelijke niveau. Om het belang van iedere prooisoort in het dieet te

bepalen en om de voedingsecologie tussen de studiegebieden en tussen de seizoenen te vergelijken, werden de *frequency of occurrence* en *relative abundance* methoden gebruikt. Aan de hand van deze waarden werden secundaire indices zoals de *feeding coefficient, index of relative importance en stomach fullness index* berekend. Er werd gebruikgemaakt van multivariate data-analyse om het dieet binnen en tussen seizoenen en locaties te vergelijken.

De resultaten gaven aan dat steenbolk en kabeljauw aangetrokken worden door de artificiële riffen van het windmolenpark op de Thorntonbank. De constante afwezigheid van beide vissoorten op de zandbank versus de hoge abundantie rondom het harde substraat bevestigen dit. De CPUE waarden varieerden seizoenaal met de hoogste waarden geobserveerd voor de zomer en herfst en de laagste waarden voor lente en winter. Er werd een duidelijke seizoenale segregatie in lengteklassen waargenomen. Kabeljauw werd in de lente en zomer vertegenwoordigd door individuen variërend van 25 tot 35cm en in de herfst en winter door individuen variërend van 35 tot 45cm. Steenbolk werd voornamelijk vertegenwoordigd door individuen variërend van 19 tot 23cm in de lente, zomer en herfst, en individuen van 23 tot 27cm in de winter. Uitgaande van de verkregen resultaten en vorige studies kan er verondersteld worden dat kabeljauw en steenbolk in de lente arriveren in het windmolenpark als juvenielen, na hun eerste jaar in ondiepe kuststreken te hebben doorgebracht. Gedurende de zomer en herfst worden deze aritficiële riffen als voedselbron aangewend. In de winter migreren steenbolk en kabeljauw naar andere gebieden. De conditie-indices varieerden naargelang de seizoenen. De hoogste waarden werden geobserveerd in de zomer voor kabeljauw en in de herfst voor steenbolk, de laagste waarden werden waargenomen in het paaiseizoen.

Het dieet van steenbolk en kabeljauw bestond uit een grote variëteit aan prooisoorten. Het merendeel van deze prooisoorten zijn obligatorische hard-substraat soorten. *Jassa herdmani*, *Phtisica marina* en *Pisidia longicornis* domineerden het dieet van kabeljauw; *Jassa herdmani*, Pisces spec., *Pisidia longicornis* en *Phtisica marina* waren de dominante prooisoorten voor steenbolk. Met de implementatie van het windmolenpark werd er een nauwe trofische relatie gevestigd tussen de WAR en kabeljauw en steenbolk, er wordt dus energie getransfereerd van de epifauna van het WAR naar steenbolk en kabeljauw. Dit benadrukt het belang van de WAR in de voedingsecologie van kabeljauw en steenbolk.

De dieetsamenstelling van zowel kabeljauw als steenbolk varieerde seizoenaal. De zomerstalen van kabeljauw werden gedomineerd door *Jassa herdmani*, de winter- en lentestalen door *Pisidia longicornis* en de herfststalen door Liocarcinus holsatus. Het lente-, zomer- en herfstdieet van steenbolk werd gedomineerd door *Jassa herdmani*, het winterdieet door *Pisidia longicornis*. Uitgaande van de multivariate data analyse konden geen significante ruimtelijke verschillen vastgesteld worden voor diëten van kabeljauw en steenbolk. Daarentegen werden er wel opvallende ruimtelijke verschillen vastgesteld in het belang en voorkomen van prooisoorten. Het gehele jaar door werd plantenmateriaal het meest frequent aangetroffen in het dieet van kabeljauw aan het scheepswrak, LCT, gevolgd door *Jassa herdmani* en *Ophiotrix fragilis*. Het dieet van kabeljauw aan de WAR werd gedomineerd door *Jassa herdmani*, *Pisidia longicornis* en *Phtisica marina*. De maaginhoud van steenbolk aan LCT werd gedomineerd door *Jassa herdmani* gevolgd door *Pisidia longicornis*. Plantenmateriaal werd ook in hoge frequenties aangetroffen. Aan de WAR was *Jassa herdmani* de meest invloedrijke prooisoort voor steenbolk, gevolgd in numerisch belang door *Pisidia longicornis* en *Phtisica marina* en in gravimetrisch belang door Pisces spec.

De Spuikom in Oostende: opstellen van een geïntegreerd beheersplan voor het terugdringen van de Japanse oester (*Crassostrea gigas*, Thunberg)

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Sinds de jaren '90 is de groei van de invasieve Japanse oester (*Crassostrea gigas*) in de Spuikom van Oostende spectaculair toegenomen. Deze proliferatie veroorzaakt problemen voor meerdere gebruikers van de Spuikom. Watersporters verwonden zich aan de schelpranden en de oesterkweker ziet de aanwezigheid van deze soort als een voedselconcurrent voor de gekweekte oesters. Bovendien wordt er verondersteld dat de dominantie van *C. gigas* het lokale ecosysteem kan verstoren en het potentieel heeft om de biodiversiteit in de Spuikom te wijzigen. Daarnaast zorgt de soort ook voor hinder aan de sluizen en de pontons. Een beheersplan dringt zich op om de proliferatie van deze invasieve soort tegen te gaan. Hiervoor werden in deze thesis drie onderzoeksluiken overspannen.

Voor het eerste luik werd de Spuikom drooggelegd om de distributie en de bedekkingsgraad van *C. gigas* in de Spuikom in kaart te brengen. Biologische parameters van negen bemonsterde riffen werden bepaald. Opvallend hierbij was dat de meerderheid van de bemonsterde oesters (89%) dood was en dat er weinig nieuw oesterbroed werd gevonden. De fauna geassocieerd met de oesterriffen bestond hoofdzakelijk uit epifauna (62%) waarbinnen de amfipoden het meest abundant waren. Infauna werd gedomineerd door oligochaeten.

Het tweede luik behandelde de temporele distributie van *C. gigas* larven. Van 24 april tot 30 oktober werd wekelijks het zooplankton bemonsterd en de abiotische factoren gemeten (temperatuur, saliniteit en zuurstofconcentratie). Chlorofyl a en suspended particular matter werden tweewekelijks gemeten. Er was een significant verschil in zoöplanktonsamenstelling tussen de seizoenen te zien. Larven van Polychaeta, Cirripedia, Brachyura, Gastropoda en Copepoda nauplii werden gevonden in de lente, terwijl in de zomer de adulte copepoden dominant waren. Naar de late zomer toe werden de bivalvenlarven en de rotiferen dominant. De bivalvenlarven konden niet tot op soortsniveau geïdentificeerd worden. De bemonsterde individuen waren immers te klein (<150µm) om op basis van morfologische kenmerken een onderscheid te maken tussen verschillende soorten.

Als derde onderdeel van de thesis werd er een inventaris van het hyper- en macrobenthos opgesteld om een geïntegreerd beheersplan mogelijk te maken. Op 22 oktober 2010 werden vier hyperbenthos en negen macrobenthosstalen genomen. Op 21 plaatsen werden sedimentstalen genomen. De hyperbenthosstalen werden gedomineerd door de invasieve kamkwal *Mnemiopsis leidyii*. De macrobenthosstalen werden gedomineerd door oligochaeten en nematoden. De samenstelling van de sedimentstalen werd gedomineerd door slib (korrelgroot < 63µm) en verwerkt in een GIS-kaart.

De Spuikom wordt gekenmerkt door een zeer lage soortenrijkdom en dominantie van enkele soorten. Vele factoren wijzen er op dat de Spuikom een verstoord systeem is. De ondiepe Spuikom bereikt snel hoge watertemperaturen, die meestal lage zuurstofconcentraties tot gevolg hebben, wat een grote stress veroorzaakt op de biota. Geëutrofieerd water dat via de sluizen binnenkomt werkt de proliferatie van Ulva species in de hand. Wanneer deze afsterft komen extra periodes van zuurstoftekort voor.

Hoewel 89% van de oesters in de Spuikom dood is moeten deze riffen toch verwijderd worden. Enerzijds is dit nodig voor de veiligheid van de watersporters. Anderzijds worden *C. gigas* larven door de riffen aangetrokken en zouden ze de riffen opnieuw kunnen koloniseren. Hoewel er weinig literatuur is over het terugdringen van *C. gigas* zou baggeren een mogelijke beheersmaatregel kunnen zijn.

Baggeren zal waarschijnlijk een minimale impact hebben op de biodiversiteit van de fauna gezien deze nu hoofdzakelijk bestaat uit opportunistische soorten. Een hoge influx van larven van mero- en holoplankton uit de haven zal een snelle herkolonisatie van deze soorten toelaten.

Om de inflow van larven afkomstig van de gekweekte oesters te verhinderen zou er enerzijds, gekweekt kunnen worden met triploïde, steriele oesters. Anderzijds zouden de sluizen van de Spuikom gesloten kunnen worden tijdens de paaiperiode om instroming van larven uit de haven te voorkomen. Het afwezig zijn van oesterbroed kan erop wijzen dat het oester herpes virus OsHV-1 in de Spuikom aanwezig is. Dit virus kan tot 100% mortaliteit veroorzaken bij larven en jonge oesters. Als het oester herpes virus OsHV-1 effectief aanwezig is in de Spuikom kan dit de aangroei van nieuwe individuen onder controle houden. Het is echter niet aan te raden dit virus actief binnen te brengen aangezien ook de inheemse *Ostrea edulis* zou worden aangetast.

Als bijkomende beheersmaatregel zouden zoveel mogelijk harde substraten zoals oude oesterzakken, houten palen en stenen verwijderd kunnen worden. Dit kan de settlement van *C. gigas* larven verlagen, maar structuren zoals pontons en schelpresten zullen nog steeds een plaats voor settlement zijn. Ook moet er rekening gehouden worden met het feit dat microhabitats de diversiteit verhogen.

Ook moet er blijvend werk gemaakt worden van de verbetering van de waterkwaliteit. Dit kan de proliferatie van Zeesla verminderen en de zuurstoftekorten die ontstaan wanneer deze afgebroken wordt, terugdringen. Zodoende kan de stress in de Spuikom verlaagd worden en dit kan voordelig zijn voor de densiteit en diversiteit van de bodemfauna.

Er moet blijvend gewerkt worden aan de verbetering van de omgevingsparameters in de Spuikom om de diversiteit op te krikken. Ook een eenmalige beheersmaatregel voor het verwijderen van *C. gigas*, zoals baggeren, zal niet volstaan en een continue opvolging zal nodig zijn.

Opname van microplastics door de mossel *Mytilus edulis*: studie van de biologische effecten

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De productie van plastic is in de afgelopen decennia toegenomen van 1,5 miljoen ton in 1950 tot 245 miljoen ton in 2008 (Plastics Europe, 2009). Samenlopend met deze toename is in die afgelopen halve eeuw de vervuiling van de oceanen, zee¨en en kuststreken door plastics en ander synthetisch, niet-biodegradeerbaar materiaal een steeds groter wordend probleem geworden: 60-80% van alle mariene vervuiling is plastic (Derraik, 2002). De aanzienlijke hoeveelheden en de duurzaamheid van het plastic vormen een belangrijk risico voor het mariene leven. De best gekende problemen met marien plastic afval hebben betrekking tot de opname ervan door mariene organismen en verstrikking van deze dieren in het afval (Derraick, 2002; Moore, 2008).

Recent echter werd de focus meer verlegd naar het risico geassocieerd met de verwering van grote stukken plastic. De effecten van kleine plastic partikels, de zogenaamde microplastics (kleiner dan 1mm), mogen namelijk niet onderschat worden. De ingestie van gedegradeerde plastic fragmenten en pellets is, op het vlak van toxiciteit, een grote reden tot bezorgdheid. Micro- en nanopartikels kunnen grote schade aanrichten door de gecombineerde effecten van hun intrinsieke toxiciteit en hun grote specifieke oppervlak (Browne *et al.*, 2007). Plastics die in het dagelijkse leven voor een groot gebied aan toepassingen gebruikt worden zijn opgebouwd uit monomeren, die uit deze producten kunnen lekken (Garrigos *et al*., 2004; Marcilla *et al.*, 2004). Maar monomeren zijn niet de enige chemicali¨en die potentieel vanuit plastics naar organismen getransfereerd kunnen worden. Additieven die tijdens het productieproces toegevoegd worden en geadsorbeerde persistente organische polluenten zijn eveneens aanwezig in de plastic partikels (Mato *et al.*, 2001); Browne *et al.*; 2007, Teuten *et al.*, 2009). De concentratie van PCB's geadsorbeerd aan microplastics zou zelfs tot een miljoen keer hoger liggen dan de concentratie in het omringende zeewater (Betts, 2008).

Aan de hand van een blootstellingsexperiment werden mogelijke effecten van de opname van microplastic door organismen aan de basis van de voedselketen nagegaan, meer bepaald bij de gewone mossel, Mytilus edulis. De mosselen werden dagelijks aan een vaste concentratie van microplastics met drie verschillende diameters blootgesteld: 10, 30 en 90µm. Hier werd dan nagegaan in welke mate de mosselen de plastics uit het water verwijderden via hun filterfunctie en of er plastic partikels doorheen de darmwand in het lichaam van de mossel opgenomen werden en indien dit gebeurde, welke groottefractie van de partikels opgenomen werd. Vervolgens werden de biologische effecten van de opname van de plastic partikels onderzocht. Dit gebeurde aan de hand van een bepaling van de voedselopname (gemeten als clearance rate) en een biomerkeranalyse, meer bepaald prote¨ınen, koolhydraten, lipiden en elektron transport systeem (ETS). De eerste drie biomerkers zijn een maat voor de energie die de mosselen ter beschikking hebben, terwijl de laatste gebruikt wordt als een maat voor de geconsumeerde energie.

Uit de resultaten van de plastictellingen bleek dat de blootgestelde mosselen wel degelijk partikels van alle afmetingen uit de waterkolom filterden. De partikels met de grootste afmetingen, namelijk deze van 30 en 90µm, werden teruggevonden in de feces van deze mosselen. En dit in dezelfde verhoudingen als waarmee ze oorspronkelijk aan de mosselen toegediend werden, meer bepaald een verhouding van 1/5. De plastic partikels van 10µm werden in veel kleinere aantallen teruggevonden. Dit valt grotendeels te wijten aan de moeilijkheid van het opsporen van de partikels op de filters. Een klein deel van deze microplastics werd teruggevonden op de filters met gedestrueerde mosselen en in de hemolymfestalen. Dit lijdt tot de conclusie dat partikels doorheen de darmwand in het hemolymfe van de mosselen terecht zullen komen. Daar enkel de kleinste partikels teruggevonden werden, lijkt er een bovengrens te bestaan voor de partikels die deze beweging kunnen maken. Deze resultaten bevestigen het eerdere onderzoek van Browne *et al.* (2008).

De blootgestelde mosselen vertoonden een significante daling in de clearance rate, en hadden bijgevolg een verminderde voedselopname. Daarnaast werd bij de biomerkeranalyse een toename in het elektrontransportsysteem van deze dieren vastgesteld, in vergelijking met de controlemosselen. Daar ETS gelinkt is aan de respiratie [correlatie tussen beide teruggevonden door Fanslow *et al.*

(2001)] betekent dit dat blootgestelde organismen een hogere respiratie vertonen dan de controles. Algemeen kan men stellen dat de metabolische snelheid zal stijgen bij organismen die zich in suboptimale condities bevinden, en dus stress ondervinden. Om de metabole kost van de stress aan te kunnen zullen de organismen hun respiratie verhogen en meer energie toewijzen aan processen die het fysiologische evenwicht zullen trachten te onderhouden.De aanwezigheid van de plastics, en dus ook de opname ervan door de mosselen zijn dus stressoren die een belangrijke invloed uitoefenen op de energiehuishouding van de blootgestelde mosselen. De combinatie van een afnemende voedselopname, en dus energiewerving, en een toenemende respiratie, dus toenemende energieverliezen, zouden in de blootgestelde mosselen een afname in energiereserves kunnen veroorzaken. Dit werd echter niet in waargenomen in de resultaten van de overige biomerkers. Mogelijk was de blootstellingsduur van de mosselen aan de microplastics nog te kort om een significante afname in de beschikbare energiefractie waar te kunnen nemen.

Tijdens het experiment hebben een groot deel van de mosselen, ongewenst, kuitgeschoten. Aangezien dit energetisch veeleisend is, zou dit mogelijks de energiehuishouding in de mosselen, en dus ook de biomerkerbepaling, be¨ınvloed kunnen hebben. Vandaar dat bijkomende analyses op de kuitgeschoten en niet-kuitgeschoten mosselen uitgevoerd werden. Het kuitschieten bleek echter geen significante verschillen te veroorzaken in de biomerkeranalyse tussen kuitgeschoten en niet-kuitgeschoten mosselen. Enkel voor de controles werd er een verschil waargenomen in de lipidefractie. Hier bleken de mosselen die geen kuitgeschoten hadden een hogere beschikbare energie te bezitten dan de mosselen die wel kuitgeschoten hadden. Tijdens het kuitschieten verhoogt de metabolische activiteit van de mosselen en zal dus een deel van de beschikbare energie aangesproken worden (Cancio *et al.*, 1999; Petrovic *et al.*, 2004).

Naast de directe negatieve effecten die de microplastics op blootgestelde organismen zullen uitoefenen, zoals in dit werk werd aangetoond, kunnen deze parikels echter ook indirecte effecten veroorzaken. Het grote gevaar van de microplastics schuilt namelijk in het grote specifieke oppervlak van deze partikels, en het feit dat ze een grote affiniteit vertonen voor persistente organische polluenten. Als deze partikels dus in het hemolymfe, en eventueel andere weefsels, van de mossel terechtkomen, zullen deze organismen in verhoogde mate blootgesteld worden aan deze POP's. Plastic marien afval brengt dus meer gevaren met zich mee dan we zo met het bote oog kunnen waarnemen. Naast de gevaren voor vertebraten, tonen deze resultaten aan dat ook kleine invertebraten te lijden kunnen hebben onder dit afval. 'Vergiftiging' van deze organismen, die zich aan de basis van het voedselweb bevinden, kan dus grote implicaties hebben voor het gehele mariene ecosysteem.

Polaire ecotoxicologie: effecten van organische polluenten op Arctische ecosystemen

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De effecten van olie op een Arctisch ecosysteem werden onderzocht aan de hand van microkosmos-experimenten, beeldanalyse en wiskundige modellen. Het bestudeerde microbiële ecosysteem was afkomstig van het oppervlaktewater van de Balsfjorden in het zuidwesten van de Barentszzee. De effecten van pyreen, een hoofdcomponent van olie, op dit ecosysteem werden in de microkosmossen gedurende tien dagen onderzocht. Dagelijks werden stalen genomen om de pyreenconcentratie te meten, het aantal autotrofe en heterotrofe micro-organismen te bepalen, alsook het aantal copepoden te tellen. Ook werden via een lineair invers model (LIM) de verschillende koolstofstromen binnen het ecosysteem in de microkosmossen bepaald.

Copepoden, fytoplankton en protozoa werden sterk in aantal gereduceerd na de toevoeging van pyreen. Bacteriën daarentegen vertoonden een meer complex beeld gezien hun plaats in het voedselweb: als direct effect daalde initieel hun aantal, maar gezien ze in mindere mate begraasd werden konden ze na verloop van tijd sterk toenemen. Ook het functioneren van het ecosysteem werd beïnvloed door pyreen. Zo werd bij copepoden, fytoplankton en bacteriën de eerste dagen een verlaagde respiratie gevonden. De bruto primaire productiesnelheid van fytoplankton per koolstofeenheid bleef constant. Na een aantal dagen van blootstelling werd een verhoogde respiratie en excretie bij fytoplankton en protozoa gevonden.

Uit deze thesis is duidelijk gebleken dat organische polluenten een impact hebben op het microbiële Arctische ecosysteem en dat deze impacten bestudeerd kunnen worden aan de hand van microkosmos-experimenten en een LIM.

Bio-economic quick scan model for fisheries management: the case of Dover sole in Belgium

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Traditional fisheries management is often unable to create the right incentives to prevent fishermen from racing against each other. At the same time the economic motives that mainly drive fishermen are not taken into account. Fisheries management is complex and there is much uncertainty and variability. However, fisheries management does not always fail, and there is a clear understanding of what is necessary for success and alternative management systems exist. Policy makers should be able to assess the different management systems available a priori. Kulmala *et al.* (2007) already provide a bio-economic model that analyses the quota systems in the Baltic Herring fishery. In this paper we adopt and modify this model. Variability and uncertainty is incorporated through Monte Carlo simulations. We test the transferability of the model to the Belgian fisheries management, and simulate three different management systems. This quick scan tool for policy assessment shows clear outcomes of both biological and economic components of a fishery. We find that under a scenario with ITQ system the fishery is the most profitable. Simultaneously, the spawning stock biomass of the population is always above the limits of the precautionary approach. We discuss the required data input and recommend the use of metiers in fleet segmentation. The model was applied to the Belgian fisheries without difficulty. The quick scan is not only workable as such, but can also be seen as a nucleus for enlargement, including more species, etc. We provide the literature with a stochastic bioeconomic model, applicable as a quick scan assessment tool for country-specific policy making. We believe that this quick scan tool could be used to obtain economic reference points, next to traditional biological reference points enabling more comprehensive decision-making in fisheries management.

Laat Cenozoische sedimentaire processen op de outer edge van de NW Iberische shelf, Kaap Ortegal

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De Ortegal Kaap is een unieke locatie in het zuidelijkste punt van de Golf van Biskaje. Het is gelegen in de noordwestelijke hoek van Spanje en onderging een uitgebreide tektonische geschiedenis. De combinatie van deze tektonische geschiedenis met de 'Mediterranean Outflow Water' (MOW) palaeoceanografie vormde de hedendaagse morfologische kenmerken op de zeebodem. Het MOW heeft een belangrijke invloed langs de Iberische rand. Het vormt de hedendaagse zeebodem als het uit de golf van Cadiz komt en noordwaarts langs de west Iberische rand stroomt als een contour stroom. In het NW van het Iberisch Peninsula draait het MOW rechts af de Golf van Biskaje in, waar het zijn pad vervolgt en uiteindelijk verdwijnt ter hoogte van de Ierse Rand. Dit zorgt voor grote contouriet afzettingssystemen over het gehele MOW stromingsgebied.
Een palaeoreconstructie vanaf het Mesozoicum tot het Cenozoicum werd opgesteld gebruikmakend van hoge resolutie seismische profielen. In het laat Aptiaan veranderde de omgeving van een continentale rift naar een passieve rand en dit leidde tot de 'Upbreak unconformity' die gerelateerd is aan de vorming van oceaanbodem in de Atlantische Oceaan. Sinds het laat Krijt werd deze rand actief door een zuidwaartse subductie onder het Iberisch Peninisula. In het laat Eoceen veranderde het gebied dan weer van een actieve naar een passieve rand wanneer de subductie van de Golf van Biskaje oceanische korst onder de Iberische plaat stilviel. Deze gebeurtenis is herkend in het gehele onderzoeksgebied als de 'C5 unconformity'. Het einde van deze compressiefase werd opgevolgd door de Betische Orogenese die de 'C3' en waarschijnlijk ook de 'C2 unconformity' vormden tijdens het Mioceen. Na het Messiniaan, aan het einde van het Mioceen, werd er door de opening van de Straat van Gibraltar voor de eerste keer MOW in de Atlantische Oceaan geïntroduceerd. Dit heeft geleid tot de vorming van twee belangrijke onconformiteiten, die geobserveerd kunnen worden in de contouriet afzettingen:

1) **De 'Cb unconformity'**: Deze is gerelateerd aan de Boven Pliocene Revolutie rond 2.4 Ma, wanneer het hedendaagse oceaancirculatiepatroon in de NE Atlantische Oceaan tot stand kwam na een afkoeling event
2) **De 'Ca unconformity'**: Deze is ontstaan na het Mid Pleistocene Revolutie, toen een shift van 41 ka naar 100 ka glaciale periodiciteit zorgde voor een meer intens circulatiepatroon na de glaciatie van NW Europa. Recent is de zeebodem op de outer shelf onderhevig aan erosie, door een complexe interactie tussen stromingen en een lage sediment input. De meest opvallende morfologische zones op de zeebodem zijn allemaal gerelateerd aan de tektonische geschiedenis en de voornaamste aanhoudende bodemstromingen.

Een multidisciplinair onderzoek, bestaande uit multibeam bathymetry, backscatter imaging, high□resolution single channel seismic profiling, Remotely Operated Vehicule (ROV) observaties en hydrografische gegevens werd toegepast om deze morfologische kenmerken te analyseren en in kaart te brengen. Het doel van deze thesis is om de dynamische setting van de koudwaterkoraal mini mounds te beschrijven in relatie met de hedendaagse hydrografische setting en het samen voorkomen met pockmarks. Vervolgens worden mogelijke genetische mechanismes onderzocht en voorgesteld over de herkomst, het proces en de timing van hun vorming. Extra aandacht wordt geschonken aan de mogelijke invloed, effecten en herkomst van fluida seepage. Uiteindelijk zullen de Ortegal Kaap mini mounds vergeleken worden met hedendaagse analogen en wordt er besproken hoe ze meer inzicht kunnen geven in de vorming van grote koudwaterkoraal mounds zoals deze in de Porcupine Seabight, de Rockall Trough en de Golf van Cadiz.

Mini mounds
De aanwezigheid van mini mounds met resten van het dood koudwaterkoraal Lophelia pertusa aan de rand van de diepe zone, meer dan 500m waterdiepte, is gerelateerd aan de geavanceerde MOW circulatie. Eveneens werd een levend koudwaterkoraal geobserveerd op waterdieptes rond 750m. Dit koraal groeit in een strikte densiteitenvelop, in tegenstelling tot de dode koudwaterkoralen in de mini mounds die net buiten deze densiteitenvelop werden gevonden.
De groei van koudwaterkoraal mounds is gerelateerd met versterkte MOW circulatie. Ze kunnen uitgroeien tot grote mounds en als een morfologische barrière optreden die de bodemstroming doet afwijken van zijn pad. De oriëntatie van de mini mound zone wordt ook geassocieerd met

bodemstromingen aanwezig in de diepe zone. Koudwaterkoralen groeiden door deze versterkte stromingen tot een verschuiving in de densiteit van de waterkolom hen dwong om te migreren naar dieper water. De interactie van MOW met deze mounds helpt bij het begrijpen van de paleoceanografie van het MOW. Dit is zeer goed gedocumenteerd voor de Porcupine Seabight en de Rockal Trough. Naast deze goedgekende mounds, komen er ook mini mounds voor langs hetzelfde stromingspad, hiervan is echter nog niet zoveel geweten, maar recent krijgen ze meer aandacht. Deze mini mounds zijn reeds geobserveerd in het noorden van de Rockall Trough, de Porcupine Seabight, de Whittard Canyon en de Guilvinec Canyon.
Voor deze thesis werd er data verzameld op het 'Massif Galicien de l'Ouest' voor de kust van Cabo Ortegal, als gedefinieerd door Le Danois (1948). Het initiële doel was om het koudwaterkoraal massief en zijn relatie met de MOW circulatie volledig in kaart te brengen.

Pockmarks
Eerdere studies in dit gebied spitsten zich enkel toe op de Mesozoische evolutie van de Galicische rand, recent publiceerde Jané et al. (2010) een studie over het voorkomen van pockmarks op de Ortegal Spur.
In het studiegebied werd een dens netwerk van pockmarks op de zeebodem tussen 250 en 450m waterdiepte geobserveerd. De vorming van deze pockmarks is gerelateerd aan NE□ZW georiënteerde breuklijnen geassocieerd met de opening van de Centraal Atlantische Oceaan. Langs deze breuken migreert een fluïdum vanuit de Albiaan afzettingen richting zeebodem. Door de gelijkenis in grote en oriëntatie tussen de mini mounds en de pockmarks, zowel als het samen voorkomen ervan, kan eenzelfde oorsprong voorgesteld worden. Echter door verder onderzoek met gelijkaardige mini mounds is het duidelijk dat de oorsprong van de mini mounds meer te maken heeft met het MOW en de juiste densiteitsenveloppe dan met een fluïdum afkomstig uit de Albiaan afzettingen.

Contourieten
De diepe zone van het studiegebied (meer dan 500m water diepte) bevat bewijs voor een Ortegal Kaap contourietafzettingssysteem (CDS), welke gevormd is door een sterk stromende MOW. De opening van de Straat van Gibraltar introduceerde dit MOW in de Atlantische Oceaan en geeft eveneens het startsignaal voor de contourietafzettingen langsheen de Iberische rand, zoals kan aangetoond worden door de 'Ca' en 'Cb unconformities'.
Nu wordt deze CDS beïnvloed door de interactie van het MOW met de lokale zeebodemmorfologie. Deze laatste wordt gedomineerd door EW georiënteerde canyons en de EW georiënteerde kam in het zuidwestelijke deel van het studiegebied. Verder onderzoek om het Kaap Ortegal CDS te ontmantelen is voorgesteld.

Conclusie
Dit multidisciplinair onderzoek is het eerste dat een meer gedetailleerde beschrijving geeft van de processen die actief zijn voor de kust van Kaap Ortegal. Belangrijke palaeotektonische en -oceanografische gebeurtenissen die meer inzicht geven in het gedrag van het MOW en zijn interactie met de lokale morfologie, en het voorkomen van mini mounds en pockmarks werden herkend. Evenals het voorkomen van een lokaal contourietafzettingssysteem dat gerelateerd is en gecorreleerd kan worden met de belangrijke contourietafzettingssystemen langs het MOW stormingspad.

Opname van microplastics door de wadpier (*Arenicola marina)*: selectieve opname en biologische effecten

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De constante vervuiling van de oceanen met plastic materialen is een enorm probleem. De biologische effecten van macroplastics op mariene organismen zoals zeevogels, zeeschildpadden en zeezoogdieren is al goed bestudeerd. De laatste jaren is het belang aan microplastics enorm toegenomen vanwege de afbraak van grotere partikels door fotodegradatie en het opzettelijk en onopzettelijk lozen van kleiner plastic materiaal. Er zijn in de literatuur nog maar weinig studies die een verband tussen de opname van microplastics en de effecten ervan op het mariene organisme beschrijven. Tot op heden zijn er al studies uitgevoerd op de tweekleppigen, stekelhuidigen, zeekomkommer, amfipoden en polychaeten zoals de wadpier (*Arenicola marina*). Plastic afval is een belangrijke vorm van vervuiling vanwege zijn duurzaamheid in het milieu, de wereldwijde verspreiding en de toename in concentratie waardoor plastics beschikbaar zijn voor opname voor een breed gamma aan mariene organismen.

De opname van plastic materialen door een marien organisme is vaak een gevolg van een niet selectieve voedingswijze waardoor er geen onderscheid gemaakt wordt tussen een voedselpartikel en een plastic fragment. Het opnemen van plastic kan een verscheidenheid aan nadelige effecten uitlokken. De meest besproken effecten zijn verstikking (*ghost fishing*), het veroorzaken van interne en externe wonden, blokkage van het spijsverteringsstelsel, verhongeringsdood, de associatie van contaminanten met plastics en het transport van invasieve soorten overheen de oceanen. Deze effecten zijn al uitgebreid beschreven voor de grotere mariene organismen, maar het aantal studies betreffende de kleinere mariene organismen is beduidend kleiner.

In dit onderzoek werd er gezocht naar een betekenisvolle relatie tussen de blootstelling van *A. marina* aan microplastics en de biologische respons als gevolg van de blootstelling. De studiesoort van dit onderzoek *Arenicola marina* is een veel voorkomende borstelworm (Polychaeta) in de sedimenten van de intergetijdenzones. In deze sedimenten leeft hij in een U- tot L-vormige gang waar hij zich voedt met organisch materiaal afkomstig van het sedimentoppervlak. Door zijn voedingswijze (*surface deposit feeder*) zal *A. marina* rechtstreeks in contact komen met de contaminatie van het sediment door microplastics. Het bepalen van fysiologische en biochemische parameters is een goede manier om de impact van blootstelling aan microplastics te bepalen. Biomerkers kunnen dienen als vroege waarschuwingssignalen voor de contaminatie met lichaamsvreemde stoffen (=xenobiotica). De impact van microplastics op *A. marina* werd onderzocht door de meting van de eiwit-, suiker- en vetconcentratie van de worm, als ook de energieconsumptie (ETS) en de cellulaire energie allocatie. De fysiologische parameters die gemeten werden, zijn het verschil in de tijd van ingraven, de verandering in biomassa en de voedselopname.

Uit de analyse van de variabelen zijn een aantal gevolgen van blootstelling aan microplastics opgemerkt. Van al de gemeten biomerkers werd er enkel een significant verband gevonden tussen de eiwitconcentratie en de blootstelling aan microplastics. De vervuiling met microplastics zal leiden tot een verhoging van de eiwitexpressie. Deze stijging in eiwitconcentratie is mogelijk het gevolg van een stressrespons waardoor er stressproteïnen geactiveerd worden in de blootgestelde wormen. Een ander gevolg van de korte termijn blootstelling aan microplastics is de daling van de biomassa op het einde van het experiment. Een mogelijke verklaring voor deze daling is de opname van sediment met een lagere voedingswaarde zonder compensatie in de voedselopname (faecesproductie). Een onverwachte respons werd opgemerkt in de tijd van ingraven voor de blootgestelde wormen. Tijdens de verversing van het sediment gingen de blootgestelde wormen zich sneller ingraven dan bij de start van het experiment. Deze sensorische respons is het tegenovergestelde van wat verwacht werd bij vervuiling van het sediment.

Tenslotte kunnen we besluiten dat de 10µm grote microplastics opgenomen worden in het circulatorisch systeem of de weefsels van *A. marina*. Heel sporadisch werd er ook microplastic van 30µm aangetroffen in de gedestrueerde wormen. De opname van microplastics in het lichaam van het organisme is afhankelijk van de grootte van het partikel en vormt een toxicologische bedreiging vanwege de aan het microplastic geabsorbeerde contaminanten.

De blootstelling aan microplastics leidt tot een verhoging van de eiwitsynthese terwijl de beschikbare energie opgeslagen in de vetten en suikers ongewijzigd blijft. Er is ook een verandering in de biomassa bij blootstelling en een daling in de tijd nodig voor ingraven. Er is nog additioneel onderzoek nodig voor de bepaling van de verblijftijd van opgenomen microplastics in het lichaam van het organisme, de effecten op de gezondheid geassocieerd met de opname en de implicaties voor de voedselketen. De boven- en ondergrens voor de diameterpartikel voor opname vanuit de darm moet ook nog onderzocht worden. De studie van de effecten van microplastic op *A. marina* als gevolg van de blootstelling gebeurde op korte termijn. In de natuur worden organismen gedurende hun hele levenscyclus blootgesteld aan een verzameling van contaminanten. Er is dus nood aan blootstellingsstudies op lange termijn om een beter inzicht te verkrijgen van de effecten van microplastics in de natuurlijke omgeving.

Voedselecologie van kustvogels: habitatvoorkeur en beperkingen door het getij

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Enorme aantallen kustvogels zijn buiten het broedseizoen afhankelijk van intergetijdengebieden langsheen kusten en estuaria. Vele van deze gebieden herbergen belangrijke populaties overwinterende vogels en sommige zijn van extra belang door hun ligging langsheen trekroutes, waardoor ze essentiële stopplaatsen vormen om te rusten en foerageren (Granadeiro *et al.*, 2007). Hoewel sommige watervogels (Anseriformes) foerageren op primaire productie zoals zeegrassen en microfytobenthos, voedt het overgrote deel van de kustvogels – voornamelijk steltlopers (Charadriiformes) – zich met ongewervelden die het sediment bewonen, aangeduid als macrobenthos (Kaiser *et al.*, 2005).

Volgens de 'optimal foraging theory' (Macarthur en Pianka, 1966), zullen vogels de snelheid van voedselopname steeds trachten te maximaliseren. Als gevolg hiervan zal er een sterke selectie zijn voor zones met een rijk aanbod aan macrobenthische prooien, dewelke typisch een fragmentarische verspreiding kennen (Van de Kam *et al.*, 1999). De selectie van voedselrijke zones lijkt vooral belangrijk te zijn in de winter, wanneer het voedselaanbod voor steltlopers over het algemeen laag is door verminderde biomassa en activiteit van het macrobenthos (Zwarts en Wanink, 1993). Bovendien stijgt de metabolische kost om de lichaamswarmte te onderhouden aanzienlijk in de winter (Kersten en Piersma, 1987). Het vinden van voldoende voedsel om in de dagelijkse energiebehoefte te voorzien is dus van levensbelang voor kustvogels die in onze regio's overwinteren.

Interessant in dit opzicht zijn mosselbanken (*Mytilus edulis)* en *Lanice*-riffen in het intergetijdengebied. Deze biogene structuren huisvesten specifieke macrobenthische gemeenschappen, die vaak meer soortendivers en rijker in biomassa zijn ten opzichte van het omringende sediment, waardoor ze als het ware ecologische eilanden vormen (Zuhlke, 2001; Rabaut *et al.*, 2007). Bovendien zijn ze eenvoudig visueel op te sporen, een groot voordeel voor predatoren op het intertidale sediment, dat een zeer homogene aanblik heeft en waar de prooien een ingegraven, verborgen leven leiden. Mosselbanken zijn dan ook welbekende, attractieve voedselgronden voor o.a. Scholeksters *Haematopus ostralegus*, Zilvermeeuwen *Larus argentatus* en Eidereenden *Somateria mollissima* (Hilgerloh, 1997). De kokerbewonende borstelworm *Lanice conchilega* (Pallas, 1766) die voornamelijk voorkomt in subtidale zachte substraten, kan echter ook intertidale populaties vormen. In zulke *Lanice*-riffen kan de worm, die een kokertje van zand en schelpengruis bouwt dat boven het sediment uitsteekt, densiteiten bereiken van duizenden individuen per m², wat een dense aggregatie van *L conchilega* inderdaad de aanblik geeft van een rif (Rabaut *et al.*, 2009). De kokerworm heeft bovendien effect op zijn habitat door het stimuleren van zuurstof- en nutriëntuitwisseling, waardoor hij een geschikte omgeving creëert voor andere soorten en zo de densiteit en diversiteit van macrobenthische organismen in het omringende sediment positief beïnvloedt (Zuhlke, 2001; Rabaut *et al.*, 2007). Het is daarom te verwachten dat *Lanice*-riffen in het intergetijdengebied, net zoals mosselbanken, een aantrekkelijk voedselhabitat vormen voor kustvogels door een verhoogd aanbod aan prooien. De weinige studies die hierover reeds bestaan kwamen inderdaad tot deze conclusie (Petersen en Exo, 1999; Godet *et al.*, 2008; Jaffré, 2009).

Even belangrijk als de aanwezigheid van rijke voedselgebieden, is echter hun toegankelijkheid. Vogels die voedsel zoeken in het intergetijdengebied zijn sterk afhankelijk van de getijbewegingen van het water, aangezien deze de oppervlakte die beschikbaar is om te foerageren voortdurend veranderen en het gedrag van vogels beïnvloeden (Burger *et al.*, 1977; Connors *et al.*, 1981; Granadeiro *et al.*, 2006). Het gebruik van een intertidaal voedselgebied kan daarom best begrepen worden als een 'dynamisch exploitatie model', waarin het gebruik ervan voortdurend verandert met de verschuivende waterlijn (Van de Kam *et al.*, 1999). Dit geldt vooral voor de zogenaamde 'tij-volgers' (bv. Bonte strandloper *Calidris alpina*), maar de beschikbare voedselgronden voor 'niet-volgers' (bv. Zilverplevier *Pluvialis squatarola)* zijn eveneens sterk afhankelijk van het getij (Granadeiro *et al.*, 2006). Vogeltelling bij laag tij, nochtans veel gebruikt in onderzoek naar kustvogels, geven daarom geen goed beeld van het gebruik van een intergetijdengebied, aangezien ze het belang van de hoger gelegen gebieden onderschatten in het voordeel van de lagere

intergetijdenzones (Granadeiro *et al.*, 2006). Tellingen gebeuren daarom beter gedurende de volledige getijdencyclus, waarmee zowel eb-vloed als springtij-doodtij cycli in rekening gebracht worden (Colwell en Cooper, 1993; Dias *et al.*, 2006).

In deze thesis werd onderzocht hoe een klein en heterogeen intergetijdengebied, waar zowel mosselbanken als *Lanice*-riffen voorkwamen, gebruikt werd door foeragerende, overwinterende steltlopers. De reactie van de vogels op de heterogene voedselomgeving werd onderzocht aan de hand van de volgende hypothesen: (1) mosselbanken en *Lanice*-riffen bevatten veel macrobenthische prooisoorten, waardoor het aantrekkelijke voedselgronden zijn voor vogels; (2) vogels verkiezen deze habitats om te foerageren; maar (3) hun habitatvoorkeur is beperkt door de getijdencyclus.

Het onderzoek werd uitgevoerd langs de Belgische kust, in het strandreservaat 'de Baai van Heist'. Hoewel dit een klein gebied is met bescheiden aantallen overwinterende kustvogels, was het een geschikt studiegebied door de aanwezigheid van beide bovengenoemde habitats (mosselbanken en *Lanice*-riffen) in het intergetijdengebied. Bovendien was er geringe verstoring van de foeragerende vogels door recreanten en was er een hooggelegen uitkijkpunt voorhanden, noodzakelijk om de ruimtelijke verspreiding van vogels waar te nemen. Gedurende enkele wintermaanden werden veldwaarnemingen uitgevoerd en werd het aanbod aan macrobenthisch voedsel in de verschillende habitats bepaald. De waarnemingen gebeurden gespreid over de getijdencycli om een betrouwbaar beeld te krijgen van het gebruik van het gebied door foeragerende vogels. Staalname van het macrobenthos gebeurde telkens bij springlaagtij, wat toeliet de volledige intergetijdenzone te bemonsteren.

Door de aanwezigheid van verschillende intertidale habitats had het heterogene karakter van het studiegebied, zoals verwacht, gevolgen voor de ruimtelijke variatie in beschikbaarheid van macrobenthische prooien. De verschillende soorten steltlopers reageerden elk op een andere manier op deze variatie in voedselaanbod, als gevolg van hun specifieke voedselecologie. Scholekster *Haematopus ostralegus* werd aangetrokken tot de mosselbanken, terwijl Bonte strandloper *Calidris alpina* de zone met *Lanice*-riffen verkoos. Zilverplevier *Pluvialis squatarola* selecteerde eveneens dit habitat, tezamen met de hoger gelegen intergetijdenzone.

Wanneer we kijken naar het aanwezige voedselaanbod, had de habitatkeuze van Scholekster duidelijk te maken met de aanwezigheid van mossels *M. edulis*. Voor Bonte strandloper en Zilverplevier daarentegen, kunnen slechts prooisoorten gesuggereerd worden die hun verspreiding mogelijks beïnvloedden, daar we geen goede kennis hebben van hun dieet in het studiegebied
Als gevolg van getijdencycli, waren deze drie vogelsoorten verplicht in andere, hoger gelegen, delen van het intergetijdengebied te foerageren dan ze zouden willen op basis van hun habitatvoorkeur. Hoewel de vogels in hun gebieden van voorkeur een maximale voedselopname kunnen realiseren, zijn de overige gebieden in de intergetijdenzone bijgevolg wellicht belangrijker voor de totale energieopname, omdat ze er – noodgedwongen – meer tijd foeragerend doorbrengen.

Samengevat, onderstreept deze studie het belang van de hoger gelegen intergetijdengebieden voor de voedselopname van overwinterende kustvogels. Een conclusie die belangrijk kan zijn in het licht van natuurbehoud, aangezien deze gebieden vatbaar zijn voor verstoring (bv. recreatie) en veranderingen in landgebruik (bv. drainage, bebouwing).
Bovendien toont de thesis aan dat het nodig is om waarnemingen uit te voeren gespreid over de getijdencycli als men het gebruik van een intergetijdengebied door foeragerende kustvogels wenst te onderzoeken.

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APPLICANTS
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Nonlinear and dynamical models for temperature reconstructions from multi proxy data in bivalve shells

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The fact that bivalve shells that are sampled from the same environment show almost the same chemical signature, suggests that such shells properly record their environment and thus offer potential to reconstruct the paleo-environment. Many efforts have been made to understand the link between the chemical signatures of the shells and their environment. Although we now have some insights in these processes, accurate temperature reconstructions are still not possible. The main problem is the fact that the incorporation of different proxies is influenced by a set of different environmental parameters for a given point in time.
In this work several approaches have been proposed to improve the temperature reconstructions. In a first instance we hoped that the combination of several proxies in a multi-proxy model would help to resolve the influences of the different environmental parameters. Even though the first results based on linear multiple regression were promising, clear nonlinear proxy environmental relationships observed in some datasets encouraged us to explore the potential of nonlinear multi-proxy models and dynamical models. At first the introduction of nonlinear models seemed to have improved the reconstructions significantly. However, this appeared to be an artifact, due to the fact that the nonlinear models used normalized data. It turned out that a similar improvement could be achieved by normalizing the data before doing a linear multiple regression analysis. The introduction of dynamical models appeared to improve model performance even more than the use of multi-proxy models.
The main achievements in this work are summarized in Fig. 1 where the model performances of the most important model types are given in root mean squared errors (RMSEs). Fig. 1 shows how the linear static models based on raw data that are generally used in sclerochronology can be improved by introducing: multi proxy models as done in Chapter 1, nonlinear models as done in Chapter 2, and dynamical models as done in Chapter 4. On the other hand the figure shows that the optimization of the proxy combination introduced in Chapter 3 and used in Chapter 5, may result in worse reconstructions.
Fig. 1 clearly quantifies the improvements achieved by the different steps made in this work and makes clear that the **best reconstructions are obtained by linear dynamical models that use Mg-information**. In the following sections every important step in this work is disused individually.

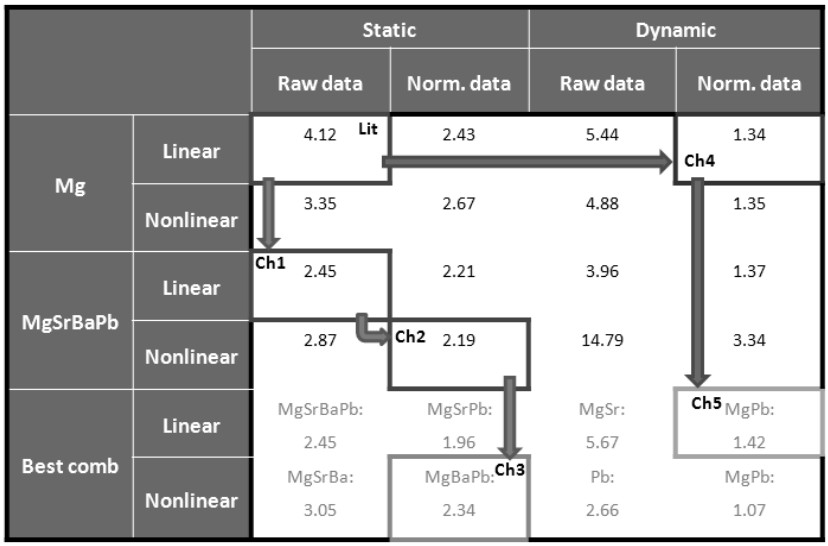

Fig. 1. In order to show how much the temperature reconstructions could be improved in this work, the model performances in RMSE (in °C) are given for different model types. The static linear Mg model obtained on raw (not-normalized data) is considered as the best reconstruction before this work. The arrow 'Ch1' represents the introduction of multi-proxy models in Chapter 1. The arrow 'Ch2' represents the introduction of nonlinear models in Chapter 2. The arrows 'Ch3' and 'Ch5' represent the proxy optimization process described in Chapter 3 and 5. The arrow 'Ch4' represents the introduction of dynamical models in Chapter 4.

1. The use of multi-proxy models

Two reasons are presented to promote the use of multi-proxy models. (1) The first one was algebraic and indicated that when the incorporation of a proxy is influenced by several environmental forcers, the environmental parameters themselves can only be described by a combination of proxies. (2) The second reason was statistical and stated that the uncertainty on a measurement is lower when more measurements are combined.

Along this work it became clear that the second reason is of higher importance. Since the improvement on the temperature reconstruction was higher by multiplying the data of one proxy than by measuring additional proxies, we have to conclude that the best improvements on temperature reconstructions are not obtained by combining proxies into a multi-proxy model.

2. The use of dynamical models

The introduction of dynamical models appeared to be much more powerful than expected (up to 2 °C in RMSE sense). Three reasons can be put forward to explain these improvements: (1) more data can be used for a reconstruction, resulting in a lower uncertainty, (2) future and past proxy data coupled to one temperature measurement during the training of the model could have reduced errors made for the unknown shell growth, and (3) the more flexible time basis can pull initially more complex proxy environmental relationships towards a linear model. The latter fact can explain why the reconstructions obtained by linear dynamical models are satisfying, even though the relationship between the proxies and their environment is clearly nonlinear.

3. The use of nonlinear models

The observation that several proxy-environmental relationships showed substantial nonlinearities encouraged the use of nonlinear models for temperature reconstruction. However, we observed that linear models performed equally if not better than nonlinear models provided both models are based on normalized data. The failure of the nonlinear models is caused by extrapolation errors: when proxy signatures of the validation data are (slightly) different from the training data, the reconstructions often show very large errors (RMSEs up to 700 °C). For more robust nonlinear models a larger training dataset should be used, solving these extrapolation problems: the more information is given in the training set, the more information is incorporated in the model and the fewer the number of extrapolations that have to be carried out during the reconstructions.

4. The use of normalized data

An important observation is the fact that the use of normalized data has a major positive impact on the reconstruction performance of all models. The overall pattern of a proxy signal appeared to be more informative than elemental concentrations or ratios. Non-normalized elemental ratios often show site specific concentration shifts or amplitude differences, which are incorrectly interpreted as temperature differences. As a result, models based on non-normalized elemental ratios are site specific and cannot be used for wider environments, which is not the case for models based on normalized data that appeared to be very generic.

5. About the proxies

A large part of the work presented in this thesis is based on the combination of two datasets that are originally published by Vander Putten *et al.* (2000) and Gillikin *et al.* (2006a). In the studied datasets four proxies were available: Mg/Ca, Sr/Ca, Ba/Ca and Pb/Ca ratios. The Mg/Ca-ratios appeared to be the most powerful temperature proxy, which confirms conclusions in the current sclerochronology literature. However, tests using the models on other species showed that models based on calcite Mg/Ca-data cannot be extrapolated to on aragonitic shells. On the other hand, we did observe that Ba/Ca ratios carry a lot of temperature information, but because the Ba/Ca ratios show to be much more site specific, the proxy cannot be extrapolated to a wide variety of environments. Pb/Ca and Sr/Ca do not carry a lot of temperature information, but combining them with Mg/Ca-ratios appears to be successful in some cases. The combination of Mg/Ca ratios with the other elemental rations can help to explain the variation in the proxy-signals. It is likely that the Sr/Ca ratios and Ba/Ca ratios explain the variations in Mg/Ca ratios that are coupled to shell growth, or to salinity variations. On the other hand Pb/Ca ratios may explain some metabolic or ontogenetic variations.

Macrobenthos structuring the sea floor: importance of its functional biodiversity for the benthic ecosystem

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The wealth of organisms and the accessibility of coastal zones have increasingly triggered exploitation of our seas in the last 150-300 years. Direct human impacts such as overfishing and associated habitat destruction, and indirect anthropogenic impacts such as sea temperature rise, eutrophication-driven or global warming-induced anoxia and the introduction of invasive species have pushed coastal ecosystems far from their historical baseline of rich, diverse, and productive ecosystems. As such, biodiversity loss can lead to a decline in ecosystem functioning, though this is often mediated through a loss in *functional* diversity (i.e. feeding and locomotion modes and biological traits such as longevity and body size).

Coastal systems are very important sites for organic matter (OM) cycling where, despite their small areal extent of about 10% of the global sea surface, about 80% of global marine benthic OM mineralisation occurs. Thus, a loss in ecosystem functioning in these areas can have important consequences at the global scale. In shallow seas like the North Sea, the main source of OM is the seasonal phytoplankton bloom. Owing to the shallowness of coastal seas, and their often mixed water columns, bentho-pelagic coupling is often tight in these systems and the benthic realm of depositional areas is therefore important in the mineralisation of the primary produced OM.
Bioturbation (solid transport) and bio-irrigation (solute transport) by macrobenthos (sediment inhabiting organisms > 1mm) play an important role in the cycling of this OM. This is because macrobenthic burial reallocates fresh detritus to the deeper, anoxic horizons of the sediment where mineralisation is retarded, delaying nutrient release to the water column, hence influencing primary production. At the same time, macrobenthic irrigation flushes the sediment with oxygen-rich water, removes toxic metabolites and stimulates denitrification, a nitrogen-eutrophication counteracting mineralisation process. These activities are crucial in OM cycling, but also provide favourable niches to other infauna, such as meiofauna (organisms between 38µm and 1mm) and bacteria.

In the Belgian part of the North Sea, the area of focus of this PhD thesis, multiple stressors act on the benthic ecosystem (*cf. supra*). As such, assessing the importance of macrofaunal density and functional identity for benthic ecosystem functioning is of paramount importance. Benthic ecosystem functioning covers amongst others, carbon and nitrogen cycling and maintenance of benthic biodiversity. These processes are outlined in **Chapter 1**, along with a description of the study site and the model organisms. Three model organisms were chosen for this study, each displaying a specific functional bioturbation/bio-irrigation behaviour: *Abra alba* (Bivalvia - Semelidae), *Lanice conchilega* (Polychaeta - Terebellidae) and *Nephtys hombergii* (Polychaeta - Nephtyidae).

In **Chapter 2**, a microcosm approach is applied to investigate the role of the three model organisms displaying functionally different traits in OM mineralisation and bioturbation. The three species were incubated in single species treatments in microcosms containing defaunated fine sandy sediment. Three density treatments of the model organisms were incorporated in the experimental design (natural, lower and a very low density). The functionally different traits in the experiments appeared to give rise to specific biogeochemical environments: whereas *Abra alba* displayed a substantial biodiffusive sediment reworking, the burrowing behaviour of *Nephtys* sp. was minimal. In contrast, the bio-irrigating activities of *Lanice conchilega* were important for oxygenation of the subsurface sediment layers. This oxygenation was linked to the stimulation of mineralisation processes such as nutrient release and denitrification by a factor 2 compared to defaunated controls. Densities of *Abra alba* appeared important in bioturbation potential, hence OM burial, whereas high *Lanice conchilega* densities sustained denitrification. These species can therefore be classified as allogenic ecosystem engineers. As such, both bioturbation and bio-irrigation, hence functional diversity, are of vital importance for ecosystem functioning in fine sandy sediments receiving high loadings of organic matter. A decrease in density of bioturbators entails a decrease in OM burial, whereas a concomitant decrease in bio-irrigators implies a decline in sediment oxygenation and denitrification, an important nitrogen-eutrophication-counteracting process in shallow coastal seas.

Establishment of enhanced biogeochemical processes such as oxygenation and removal of toxic metabolites as observed in Chapter 2, promotes co-habiting infauna, but studies on a detailed taxonomic level and high spatial resolution are very scarce. In **Chapter 3**, therefore the effect of macrofauna with functionally different bioturbation traits on the distribution and diversity of smaller infauna as nematodes, was investigated. The three model species were introduced in microcosms containing fine sandy sediment, however this time inhabited by the natural nematode population. Nematode survival was especially enhanced in bio-irrigated sediments as opposed to bioturbated and control sediments. Mainly non-selective deposit feeding and epistratum feeding nematodes responded to the presence of macrofauna, and the effect on these nematodes was most pronounced in sediments irrigated by *Lanice conchilega*. Along the length of the tube, increased densities and diversity were observed. In sediments reworked by *Abra alba*, mainly subsurface peaks in density were noted and nematodes clearly avoided the surface layer that is constantly cleared by the bivalve's siphons. These patterns demonstrate the ecosystem engineering capacities by *Abra alba* and *Lanice conchilega*. Apart from the sheltering effect of the tubes or shells (autogenic ecosystem engineering), bioturbation and bio-irrigation create specific biogeochemical niches through oxygenation, metabolite removal and probably stimulation of bacteria in the mucous tube linings and faecal pellets (allogenic ecosystem engineering).

Yet, the question whether the positive effects of bioturbation and bio-irrigation on nematodes were linked to oxygenation, to food supply or to both remained unresolved. In **Chapter 4**, we explored the nematode feeding dynamics after a simulated food pulse in both biologically mixed and physically mixed sediments. Indirect, facilitative actions go along with negative, direct actions such as disturbance, predation and competition in biologically mixed sediments, while physically mixed sediments are, apart from disturbance, free of direct interactions. A ^{13}C labelled diatom was added to microcosms containing single species treatments of the bioturbator *Abra alba* or the bio-irrigator *Lanice conchilega*, to control microcosms and to a treatment in which the upper 2cm was regularly mixed manually. On the one hand, positive effects of macrofauna were expected through their mixing of diatoms into the sediment and concomitant increased food accessibility for nematodes. On the other hand, negative structuring effects of macrofauna were surmised, through competition, predation and disturbance. Nematode survival and subsurface peaks in nematode density profiles appeared again most pronounced in the bio-irrigator treatment. Nematode specific uptake of the added diatoms was highest in absence of macrobenthos and where the diatoms were homogenised in the sediment. This could be related to enhanced accessibility in the physically mixed sediments (dilution over upper 2cm). However, fresh diatoms revealed to represent only a limited food source for nematodes and therefore the macrobenthic effect consisted essentially of *facilitating nematodes through niche creation*.

Chapter 5 explores the functional role of the selected macrobenthic species in terms of bentho-pelagic coupling. Benthic and pelagic food sources on the one hand and macrobenthic model organisms as consumers on the other hand were sampled from early spring till autumn. Fatty acid biomarkers were applied as tracers for the assimilation of food sources. The diet of *Lanice conchilega* was characterised by bacteria and diatoms, while that of *Nephtys hombergii* also showed diatoms, but more dinoflagellates and invertebrates as prominent food sources. The diet of both species demonstrated a seasonal transition from bacteria and *Phaeocystis* to assimilation of poly-unsaturated fatty acids (PUFA) originating from diatoms. In addition, accumulation and/or biosynthesis of PUFA in *L. conchilega* upon bloom deposition was demonstrated, which is probably related to energy storage for gametogenesis. PUFA are *essential fatty acids* in the metabolism of higher organisms and therefore, increased concentrations in benthic invertebrates such as *Lanice conchilega* and *Nephtys hombergii* constitute an important trophic link towards the flatfish species preying on the latter.

The knowledge on the functional role of the selected macrobenthic species is summarised and a "functional ID-card" for *Abra alba*, *Lanice conchilega* and *Nephtys hombergii* is created in **Chapter 6**. The results of the PhD thesis are put in a wider perspective through comparison with literature on bioturbators co-occurring with the selected species and by framing their importance in the actual threats marine ecosystems are confronted with upon loss of such allogenic ecosystem engineers.

In conclusion, it is clear that beneath the sediment surface, allogenic ecosystem engineers such as *Abra alba* and *Lanice conchilega* establish favourable niches for co- habiting infauna through oxygenation and OM processing and burial; functions that do not only have a large impact on infaunal biodiversity in se, but also on global carbon and nitrogen cycling. Given the large anthropogenic pressure in the North Sea, our study area, it is conceivable that for the maintenance of benthic ecosystem functioning, losing large bioturbators from muddy and fine sandy areas may be similar to losing epifaunal species such as bryozoans and sponges from areas of coarser, mixed sediment. Because these species obviously have multiple ecological roles, their loss could have

effects that extend beyond their own demise to resonate throughout the ecosystem. Their management, therefore, requires particular attention to their function in ecosystems.

Diversity and dynamics of protist communities in subtidal North Sea sediments in relation to metal pollution and algal bloom deposition

Pede Annelies

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The overall objective of this study was to obtain a better insight in the interactions between microbial communities, metal contaminants and algae-derived organic matter in subtidal, metal-contaminated sediments in the Belgian Coastal Zone (BCZ). The BCZ is characterized by extensive, annual spring phytoplankton blooms, and it has been estimated that 24% of the phytoplankton production is deposited onto the sediments. Remineralisation of this phytodetritus has been shown to lead to effluxes and hence bioavailability of trace metals (TM). The activity of benthic microbial organisms (pro- and eukaryotes) has been pointed out as one potential factor acting upon the release of TM into the water column. It remains unclear however, how microbial communities, phytodetritus deposition and TM behaviour interact. In order to predict/understand the response of marine ecosystems to metal contamination and algal bloom deposition, good baseline knowledge of the inhabitants of this environment is required. During this study, we focussed on the protist (~unicellular eukaryotes) communities, as these are largely understudied compared to bacterial, meio- and macrobenthic communities, despite their important role in the benthic food web, the functioning of the microbial loop and benthic-planktonic coupling of cycles of matter and energy.

During two field campaigns (in 2007-2008), we studied the diversity and spatio-temporal variation in diversity and community structure in the subtidal sediments of the BCZ in relation to a suite of physical, chemical (incl. TM) and microbiological parameters. The *in situ* studies were complemented with laboratory experiments in which sediment cores were incubated under various environmental conditions, viz. with and without phytodetritus deposition, and with different arsenic (As) concentrations. This not only allowed giving a more detailed picture about the effect of phytodetritus deposition on protist community structure and trace metal mobilization, and their interaction, but also to assess the impact of different degrees of As contamination on protist community structure in these marine sediments.

First (Chapter 2 of the thesis) we described microeukaryotic community composition in 9 BCZ stations with different granulometries and TM loads, before and after the spring phytoplankton bloom and compared the upper sediment layer (0-1) and deeper (9-10cm) layers. Variation in community structure was studied using 18S rDNA-based DGGE fingerprint analyses of microeukaryotic communities, complemented with the construction of group-specific (ciliates and cercozoans) clone libraries. Our results showed that microeukaryotic diversity was dominated by Stramenopila (mainly diatoms), Metazoa and Fungi. Protozoan diversity was underestimated based on DGGE analyses with general eukaryotic primers, but the clone libraries using group-specific primers showed that especially ciliates were much more diverse. Our data revealed that sediment type was the prime variable determining microeukaryotic community structure, and its overriding influence probably masked temporal and depth-related variability. Metals were strongly correlated to the sediment characteristics (grain size, CHL *a*, silt content); the effect of the trace metals on community composition could not be distinguished from the differences in sediment type.

Then (Chapter 3 of the thesis) we performed a more detailed, monthly analysis of protist community variation with depth (0-10 cm) in one silty, metal-contaminated station, for the period February to July 2008 (including periods of intense algae blooms). Microeukaryote and protozoan community composition changed with depth (~ redox, sulphides and pH) and with time, from February to July (~phytoplankton bloom deposition), with especially May and July being distinct. Increased microbial mineralization caused pronounced changes in the redox environment and the bioavailable metal concentrations in the sediment, which correlated with the observed seasonal and vertical variation patterns in community structure. Eh and pH were the dominant factors structuring the communities, but trace metals as well had a significant, independent impact (14-19 %) on the variation in microbial community structure.

The effects of phytoplankton bloom deposition and TMs on the protist communities were analyzed in more detail in two microcosm experiments.

In the first experiment (Chapters 4 and 5 of the thesis), the deposition of a phytoplankton bloom was simulated in metal-contaminated sediment cores, and sampling was performed immediately (2h), 2 days and 7 days after the start of the experiment. We focussed on the effect of bacterial mineralization of the phytoplankton-derived detritus on the release of metals and also studied the effect of the phytodetritus deposition on the structure of the total and active bacterial and microeukaryotic communities (with focus on Protozoa), and assessed how this related to metal mobilization. This allowed giving a more detailed picture about the short-time response of benthic microbial communities to organic matter enrichment and metal contamination, as well as the potential role of microbial communities in metal mobilization.

We observed that the onset of mineralization (as revealed by CLPP analysis) was very fast and started within 2h after phytodetritus deposition. Increased bacterial production was observed after two days, while bacterial biomass was stable and probably controlled by heterotrophic nanoflagellates (HNF). A clear link was established between heterotrophic microbial activity and effluxes of the TMs As, Co and Mn. Furthermore**,** DNA- and RNA-based fingerprints of bacteria and Protozoa showed distinct changes in the total and active community structure as a consequence of the algal enrichment, and with time. The enrichment effect was most pronounced after 2 and 7 days for bacteria and Protozoa respectively. Our results suggest that phytodetritus deposition activates and stimulates the microbial loop, via changes in bacterial activity, biomass and community composition, together with subsequent changes in numbers and relative abundance of heterotrophic nanoflagellates and ciliates, and composition and activity of protozoan communities. No effect of the metal fluxes was observed for bacterial and microeukaryotic diversity (~ species richness). Calculations based on our results suggest that during phytoplankton blooms the microbial activity alone may induce the release of substantial amounts of dissolved As in areas of the BCZ covered by muddy sediments.

In the second microcosm experiment (Chapter 6 of the thesis) we studied the effect of As, a notoriously toxic TM, on active protist communities (based on 18S rRNA-DGGE analyses). Sediments from a metal-contaminated silty station and an unpolluted sandy sediment were spiked with a range of As concentrations (0-960µg L^{-1}) and incubated in the dark for 2 days. Diversity (~number of DGGE bands) significantly decreased at contamination levels ≥ 480µg As L^{-1} in both sediment types, but the decrease was more pronounced in the sandy (43%) than in the silty sediment (32%), suggesting higher tolerance to As contamination in the silty sediment. In addition, a significant shift in community composition occurred at contamination levels ≥ 120µg As L^{-1} and again at ≥ 480µg As L^{-1} in silty sediment. Surprisingly, the effect of As on protist community composition was not significant in the sandy sediment. Fungi responded most sensitively to high As concentrations, while only some ciliates increased in relative abundance with higher As levels. These included representatives from various classes such as the *Phyllopharyngea, Spirotrichea, Litostomatea* and *Colpodea*. The observed responses contributed to the interpretation of OTU-specific positive and negative correlations with several metals that had been found in chapter 3 and 5, as in natural environments, it was not possible to isolate the effect of the metals from that of the environmental variability. Indeed, trace metals often strongly co-vary with many physico and- biogeochemical parameters.

Finally (In Chapter 7 of the thesis), the results of the field campaigns and the microcosm experiments were integrated and discussed. An overview was given of the overall composition of the microeukaryotic communities in the subtidal sediments of the BCZ. Generally, Stramenopila, Alveolata, Fungi, Rhizaria, and Amoebozoa were the dominant groups, ecologically important as primary producers (mainly diatoms), grazers (Rhizaria, Alveolata, Amoebozoa, heterotrophic stramenopiles), saprobes (Fungi) or pathogen-parasites (e.g. Marine Alveolates Group I, several heterotrophic Stramenopila, e.g. *Pirsonia* sp.) in these sediments. The importance of spatial and seasonal variation in various environmental factors was demonstrated for shaping microeukaryote community structure and diversity, with a pronounced impact of sediment parameters and phytoplankton bloom deposition on the activity and composition of the communities. Finally, we can conclude that microeukaryotic communities in the sediments are affected by trace metals, as evidenced by both the field and experimental data.

Diversity and ecosystem functioning in estuarine intertidal microphytobenthos

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Humanity has become a major biogeochemical force and human domination of the planet has caused massive destruction and fragmentation of natural habitats, eutrophication, climate change, acidification, etc. which caused a dramatic biodiversity loss. This biodiversity crisis raised concern about the consequences of biodiversity loss on ecosystem properties and the goods and services these ecosystems provide to humanity.

The main aim of this PhD thesis was to gain a better understanding of the diversity and functioning of estuarine benthic microalgae communities. Estuarine ecosystems provide some essential ecosystem services to humans such as carbon fixation, sustaining fisheries, coastal protection and nutrient cycling. Although estuaries cover relatively small areas on a global scale, their importance for several biogeochemical processes is disproportionately large. We focused on benthic microalgae inhabiting estuarine sediments; these algae have many essential functions for estuarine and coastal ecosystems: e.g. they are the basis of the food chain for many coastal species, mediate nutrient fluxes and stabilize sediments.

A fundamental requirement to gain insights in biodiversity and ecosystem function relationships is a solid knowledge of the diversity. Assessing diversity is not as trivial as it may seem at first, especially in microbial communities. Traditionally, species have been defined based on morphological properties. A multitude of molecular studies however have demonstrated that morphologically defined species often consist of several genetically distinct lineages. Such genetically distinct but morphologically indistinguishable species are called 'cryptic species ', whereas the term 'pseudocryptic species ' refers to the occurrence of morphologically similar species which at a closer look do exhibit subtle morphological differences between species. In most cases it is unknown whether (pseudo)cryptic species differ in their ecological preferences or whether they are functionally equivalent. This notion is not only important for questions relating diversity and ecosystem function, but also to understand mechanisms that promote cryptic species coexistence.

In **Chapter 2**, we used sequence data of 3 different genetic markers (ITS rDNA, the 18S rRNA gene and *rbc*L) together with cell wall morphology to show that estuarine populations of the widespread and common benthic diatom *Navicula phyllepta* Kütz. consist of pseudocryptic species. Moreover, we show that these pseudocryptic species differed in their tolerance to low salinities (<5 practical salinity units, psu), which was refiected by their different (but widely overlapping) distribution in the Westerschelde estuary (the Netherlands). Our results show that *N. phyllepta* sensu lato comprises different species with specialized ecophysiological characteristics rather than generalists with a broad adaptability to different environmental conditions.

In **Chapter 3** we further investigated the ecological divergence in closely related (pseudo)cryptic microalgae and assessed pattern in phylogenetic relatedness and ecological niche similarity. We explored if thermal niches can evolve fast on an evolutionary timescale resulting in regular switches between climates or if these niches are instead highly conserved. We composed a set of closely related strains of the globally distributed diatom genus *Cylindrotheca*. We collected strains from a wide range of marine habitats, from coastal plankton to sea ice and intertidal mudflats. We first inferred the evolutionary relationships of these strains using a multi-locus DNA dataset and obtained a well-resolved phylogeny. We then determined temperature preferences of closely related lineages in laboratory experiments. Combining the molecular phylogeny with the thermal niches of lineages revealed a very weak phylogenetic signal in thermal niche characteristics. This indicates that closely related species tend to differ more in thermal niche than expected by a random walk model. This seems to be caused by a combination of adaptive evolution and frequent shifts in environments in related lineages.

Species specific niches and functional traits are not only important for species coexistence and biodiversity-ecosystem function relations (see below), they may also determine how species can cope with disturbance. In **Chapter 4**, we examined the relations between the hydrodynamic

disturbance, biomass, species diversity and functional group turnover in estuarine intertidal microphytobenthos. We used an extensive dataset of benthic diatom assemblages covering a wide range of hydrodynamic disturbance to show that growth form and cell size are important traits to predict the effect of disturbance on functional group species richness. Total microphytobenthos species richness displayed a unimodal relationship with hydrodynamic disturbance and standing stock biomass. Our results are consistent with the intermediate disturbance hypothesis which implicitly assumes that there is a trade-off in functional traits determining competitive ability and disturbance tolerance. These trade-offs lead to maximal diversity when competitive and disturbance tolerant species are able to coexist.

In **Chapter 5** we assessed the effects of species diversity on productivity of intertidal microphytobenthos. We used naturally co-occurring diatom species from intertidal mudflats to experimentally assemble communities with decreasing diversity. Our results demonstrate a highly positive biodiversity effect on production, with mixtures outperforming the most productive component species in more than half of the combinations. These strong positive diversity effects could largely be attributed to facilitation and complementarity effects. In addition, we show mechanistic evidence for facilitation which is partly responsible for enhanced production. We show that a strain of *Cylindrotheca closterium* has the ability to significantly increase its biomass production in response to substances leaked into the culture medium by other diatom species. In these conditions, the species drastically reduced its pigment concentration, which is typical for mixotrophic growth.

In **Chapter 6**, I show that, next to positive, facilitative interactions, direct negative interactions (allelopathy) can strongly influence species composition in microphytobenthos. I show that cell cultures of the marine benthic diatom *N. cf pellucida* exude metabolites with strong allelopathic effects. All nine competitor species tested were inhibited in their growth and some in their photosynthetic efficiency as well. In addition, I show the occurrence of reciprocal, density dependent allelopathic interactions between *N. pellucida* and two other marine benthic diatom species, *Entomoneis paludosa* and *Stauronella* sp. These results suggest that allelopathic interactions might be common in benthic microalgal communities and may explain small-scale spatial distribution patterns observed in nature.

In **Chapter 7**, I demonstrate the physiological and molecular basis of allelopathic interactions caused by *Nitzschia* cf. *pellucida*. I show this marine benthic diatom produces chemical cues that cause chloroplast bleaching and a reduced photosynthetic efficiency leading to growth inhibition and massive cell lysis in naturally co-occurring competing microalgae. Using headspace solid phase microextraction (HS-SPME) - GC-MS, I demonstrate that this diatom exudes a diverse mixture of volatile iodinated and brominated metabolites including the new natural products cyanogen bromide (BrCN) and cyanogen iodide (ICN) which exhibits pronounced allelopathic activity. Besides these effective metabolites, this diatom also produces a diverse mixture of mono- di- and trihalomethanes, halogenated acetaldehydes and iodopropane with comparatively lower allelopathic properties. Production of these toxins is light-dependent with a short toxin burst after sunrise. This labile compound thus acts as a short-term signal, leading to daily ‘cleaning ‘ events around the algae. We show that the allelopathic effects are H_2O_2 dependent and therefore link BrCN production to haloperoxidase activity. This novel strategy of chemical warfare is a highly effective means of biofilm control. Obviously, such strategy contributes to complex micro-landscapes maintained by interacting species and may boost the small-scale patchy growth habits of biofilm forming species. Our results also provide a potential explanation for the poorly understood role of volatile halocarbons from marine algae which contribute significantly to the atmospheric halocarbon budget.

Overall, our results contribute to the understanding of the species composition and functional organization of complex phototrophic biofilms and its consequences for ecosystem functioning. We suggest that cryptic diversity is widespread among estuarine diatoms and that this diversity is linked with ecophysiological differentiation and habitat partitioning by closely related species. Over large environmental gradients it appears that lineages behave in a conservative fashion, in the sense that they are limited in their distribution to suitable hydrodynamical conditions. At the local scale, strong positive and negative interactions (facilitation, allelopathy) seem to be important in these diatom communities and have a strong influence on the functioning of this ecosystem.